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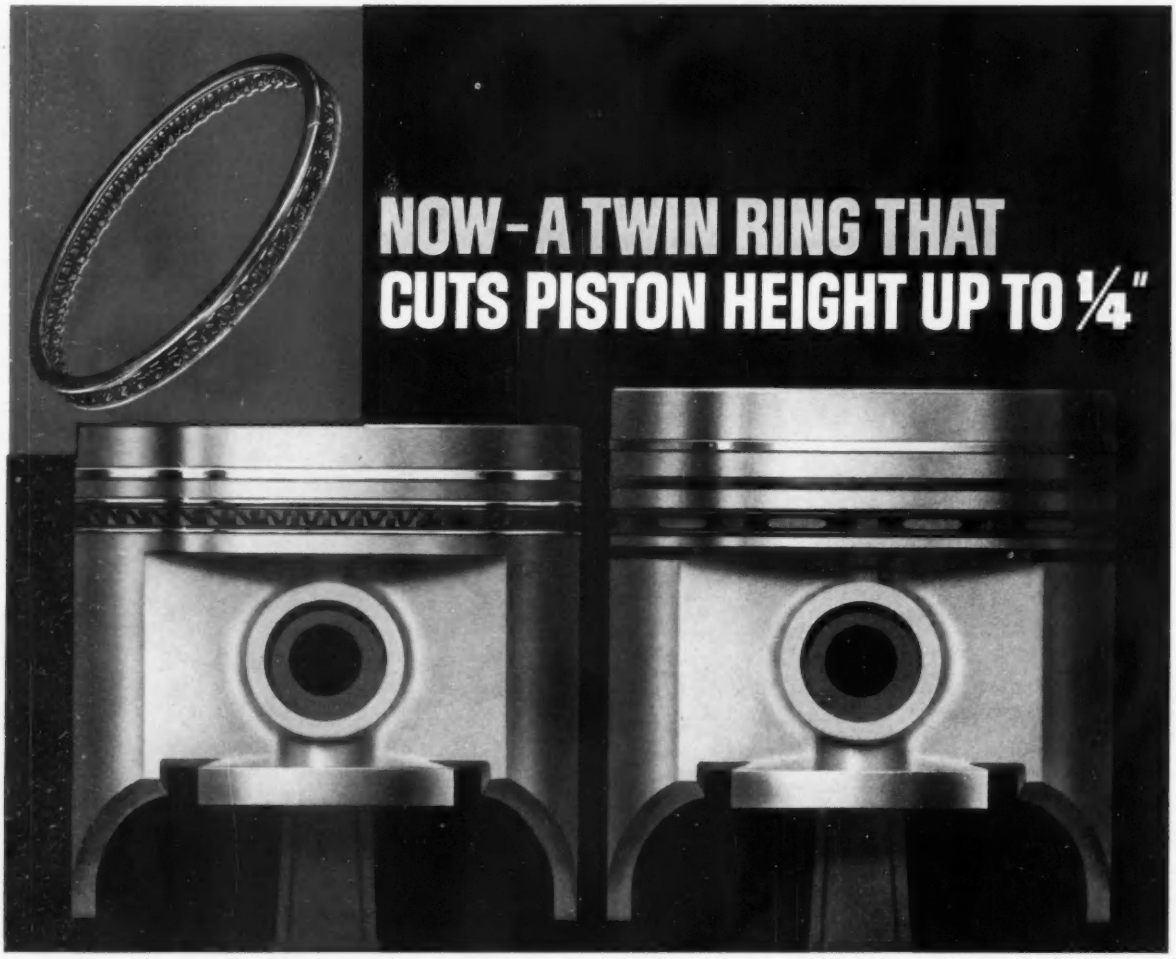

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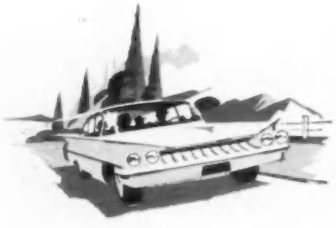

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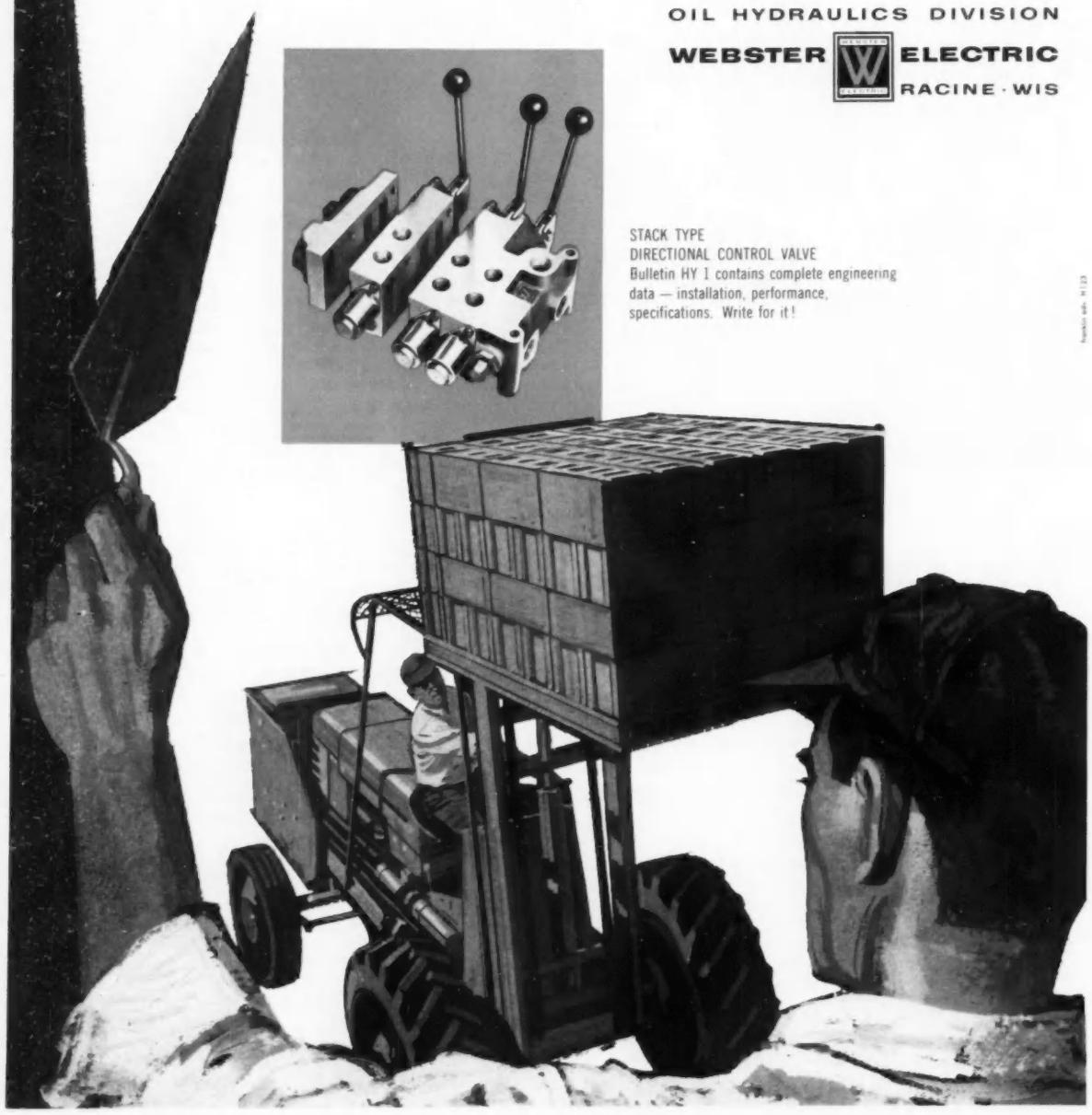

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FUELS & LUBRICANTS

Effect of Oil Change Interval on Low-Temperature Wear and Deposit-Forming Characteristics of Crankcase Oils, D. W. GOW. Paper No. S-233. A program was undertaken to evaluate the low-temperature corrosive wear resistance of oils when new and after being used in service for several mileage intrevals. Results show that: (1) ability of MS oils to combat low-temperature corrosive wear is significantly reduced when oils are used for extended mileages; (2) While most MS oils tested gave similar protection against 1-t corrosive wear when new, some lost their effectiveness more rapidly than others as mileage was accumulated; (3) when used for extended periods, the capability that MS oils have for providing protection against the formation of 1-t engine deposits is reduced markedly.

GROUND VEHICLES

Compact Cars by American Motors, R. F. JENSON. Paper No. S-231. Discusses why Americans are turning, in increasing numbers, to compact cars; and the philosophy behind American Motors concept of such cars. Covers problems involved in designing cars with minimum overall length; design features of Rambler; effect of weight on performance.

All Trucks Can Be Diesel — Fact or Fancy, E. R. KLINGE. Paper No. S-237. Covers: the diesel-engine market; essential characteristics of diesel engines; a simple economic analysis for diesel-engine application; hypothetical application of diesel engines, including future diesel engines.

Electrical Remote Control Systems — Their Application and Advantages, J. T. OSTERMAN. Paper No. S-238. Discusses the opportunities for design freedom, operational ease, and cost saving potentially available with electric controls. Such systems utilize static or dynamic sensing devices, signaling electric power multiposition actuators, or electric-hydraulic transducers. Several typical sensing devices are also described, such as transistorized electronic rate meter and differential presure switch.

Place of Gas Turbine in Off-Highway Equipment, JOHN M. STEPHENSON. Paper No. S-239. With small, lightweight turbines now available delivering 1000 hp and up, author says a new generation of large, highly mobile vehicles can be built that have hardly been possible at all with piston engines. Paper summarizes the engine and transmission characteristics that the author believes will be required by these new vehicles; then describes what some of them might look like.

Computers and Earthwork, BASIL MIKHALKIN. Paper No. S-240. Discusses how computers are being used in the design of highways. Author forsees the day when we will have almost automated highway design. All of the standard design work will be done by computer, and only the exceptional nonstandard cases will be handled by manual computations.

Cold Starting Diesel Engines with Low Voltage Ignition, I. P. ATWELL, W. P. BRUMBACK, and W. R. MANTHEY. Paper No. S-241. The feasibility of starting diesel engines at –25 F, using JP-4 fuel, by means of low voltage ignition, is discussed. Authors report that, although results of the study indicate a definite potential for application of low voltage ignition to cold starting of diesels, the work has not progressed sufficiently for cost analysis or finalized system design. Work on the program is continuing.

High Durability Electrical Equipment for Earthmovers, W. C. EDMUNDSON. Paper No. S-243. Discusses what is being done about the problem of building reliable electrical equipment for earthmoving machinery. Author shows what has become available recently, and is already adopted in some quarters, and proposals that have been evaluated and are ready to be promoted to the user.

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Vehicles, LEONARD J. NUTTALL and MANNING L. BALCOM. Paper No. S-244. General Electric Model 720 gas turbine is considered as prime mover for earthmoving, aircraft, marine, industrial, and military tracked vehicle applications.

When Does Guaranteed Maintenance Fit into Fleet Operation, ROBERT HAMILTON. Paper No. S-246. Describes what guaranteed maintenance is, to whom it might apply, how the agreement and rate are established, manufacturer's and owner's responsibilities, and benefits.

Use of Diesel Power in Taxicab Operation, DAVID N. VIGER. Paper No. S-248. Discusses reasons why diesel is suitable for taxicab operation. Includes brief specs for Perkins P4C diesel; also compares fuel and repair costs for typical Plymouth taxi, both diesel and gasoline powered.

Developing Tires for Land Speed Record Car, E. W. McMANNIS. Paper No. S-249. Covers steps taken to develop Land Speed Record (LSR) tires for Mickey Thompson's Challenger car, which established the American land speed record of 363.67 mph, and four new international records last fall on Bonneville Salt Flats.

Suspension Design for Single Unit Construction, F. R. KISHLINE, T. M. LAWLER, Jr. Paper No. 143A. Significant observations based on experience of American Motors Corp., exemplifying solutions to problems in development of front and rear suspensions for unitized cars; factors relating to ride, handling, shake, durability, and noise as affected by suspension design; road noise, tire thump, and tire roughness are principal noises influenced by front suspension design; isolation and tuning techniques.

Dimensional Effects on Noise and Vibration in Unitized Construction, F. J. HOOVEN. Paper No. 143B. Problems of controlling noise and vibration; examination of design features incorporated for this purpose in Lincoln and Falcon cars produced by Ford Motor Co.; methods of noise and vibration analysis; application of body frame electrical and mechanical analog; evaluation of various types such as front and rear suspension noise problems, axle gear noise, and engine and propeller shaft vibrations; engine bending oscillations; difference in treatment of two cars.

Control of Noise and Vibration in Unibody, J. R. FARNHAM. Paper No. 143C. Changes involved in transition from frame type cars in 1960 Unibody cars produced by Chrysler Corp. most important being elimination of disturbing sounds and vibrations in passenger compartment; steps taken for areas which required improvement, viz, suspension isolation, rear axle noise, engine mounts and driveline; speaker panel test employed to determine actual areas inside confines of passenger compartment where road noise is more audible.

Suspensions from Ground Up, C. M. RUBLY. Paper No. 143D. Development of new tire and compatible rim to help suspensions overcome handling deficiencies of rear engine car Chevrolet Corvair; design of front and swing axle independent rear suspension and its attachment to integral body; outstanding aspects of swing axle with regard to roll couple distribution front to rear; body structure and relative stiffness obtained.

Analysis and Simulation of Automobile Ride, R. H. KOHR. Paper No. 144A. Servo-controlled motion simulator which can seat two passengers, developed by General Motors Corp. for use in ride analysis, takes into account road, car, and passenger; ride simulator is composed of tape recorder to provide road wave inputs into system; analog computer takes in signals from tape recorder and, from these inputs to car's suspension, determines what car body motions would result; motion simulator reproduces body motions determined by computer; details of components.

Bodies in Which We Live, W. H. JACKSON. Paper No. 146A. Paper deals with physiological aspects of heating, cooling and ventilating automobile; human body as heat transfer device; conditioned air requirements; most important factors affecting hu-

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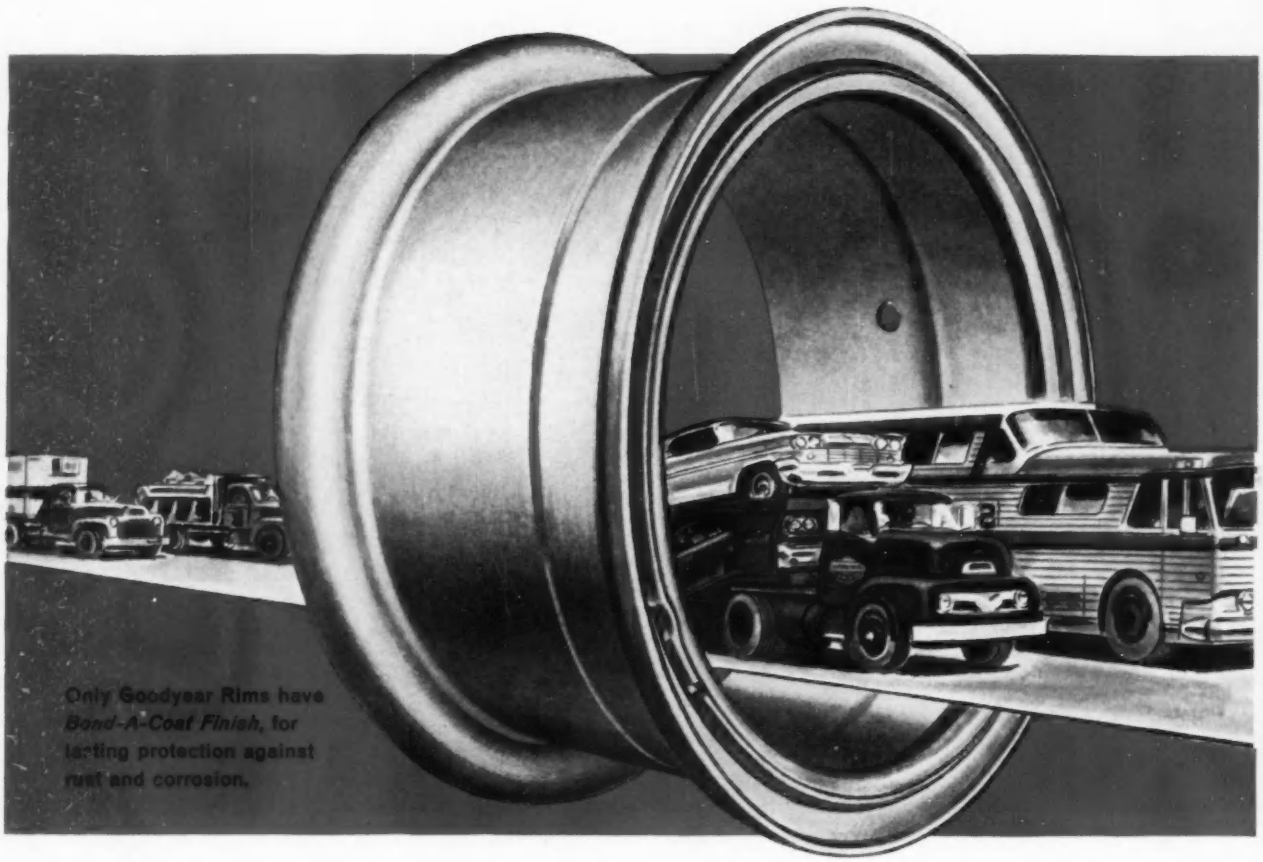

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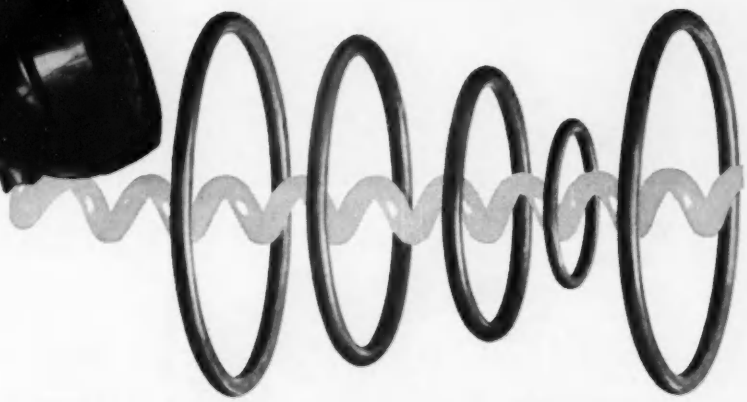

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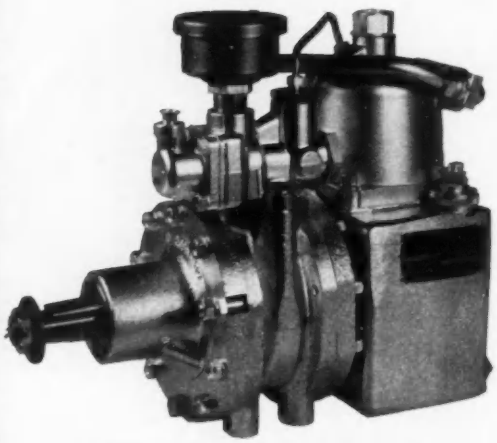
When you specify braking systems for heavy-duty vehicles, you can choose the system best suited to your needs, and get the complete system from Wagner. Only Wagner can supply components for all braking systems—everything from actuating systems to foundation brakes for straight air, hydraulic, or air-over-hydraulic brakes. The two new components and the time-proven rotary air compressor shown below point out the product development and the years of experience that have kept the name Wagner Lockheed first in braking for many years.

HEIGHT CONTROL VALVE

Used with vehicles equipped with air suspension to keep the floor height constant despite variations in loading. Efficient air usage sharply cuts compressor pumping time—lengthens compressor life.

AIR CAM BRAKE

Designed for outstanding performance, this brake is completely interchangeable with Wagner Lockheed hydraulic foundation brakes. Standardization on Wagner brakes can simplify vehicle assembly lines—reduce inventories on axles—speed production.

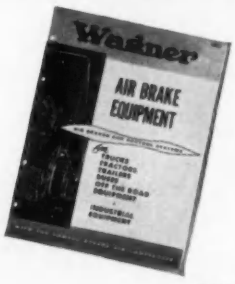


ROTARY AIR COMPRESSOR. Proved by billions of miles of low maintenance service on thousands and thousands of vehicles. It provides all the advantages that only rotary compression can bring: rapid pressure recovery... cooler operation... smoother operation... quieter operation and longer operating life.

CONSULT YOUR WAGNER AIR BRAKE SPECIALIST

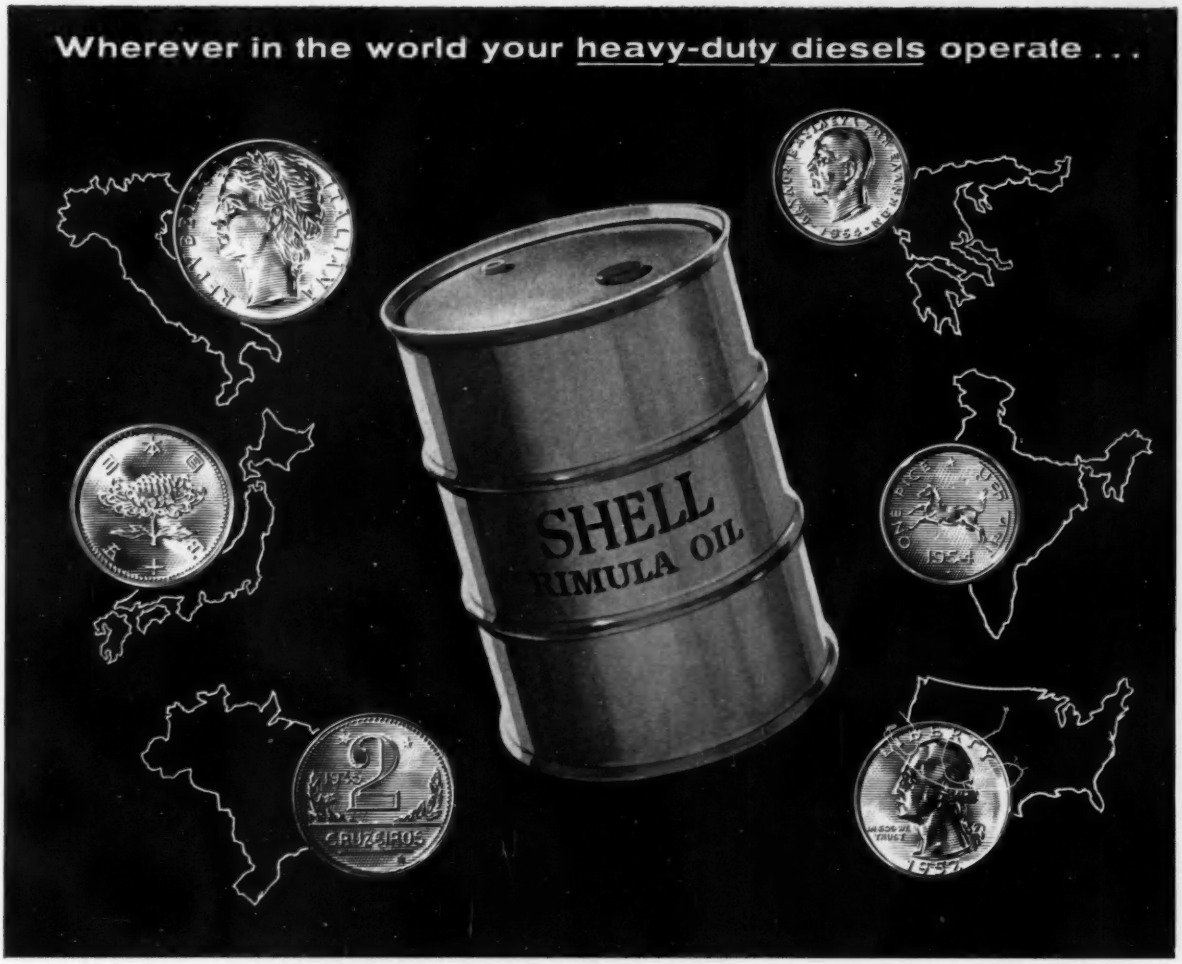
Let him help you with your specifications, and also ask him about the engineering consulting service available from Wagner.

Wagner Electric Corporation
6378 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI



WK60-3

LOCKHEED BRAKE PARTS, FLUID, BRAKE LINING and LINED BRAKE SHOES • AIR HORNS • AIR BRAKES • TACHOGRAPHS • ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES



Shell Rimula Oil is there

Other outstanding Shell Industrial Lubricants

Shell Tellus Oils – for hydraulic systems

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Shell Macoma Oils – for extreme pressure industrial gear lubrication

Shell Voluta Oils – for high-speed quenching with maximum stability

AN INTERESTING FACT!
Every Shell Branded Industrial Lubricant is named for a sea shell. Shown here is the Rimula exquisita.

Around the world, Shell Rimula Oil is available—under the same brand name and providing the same efficient lubrication that your domestic customers rely upon.

Rimula® Oil is a heavy-duty oil that provides the finest crankcase lubrication for today's supercharged diesels. It has proved more than a match for the greatly increased engine ratings, high temperatures and pressures encountered in modern diesel operation. Rimula Oil successfully resists every destructive force that tends to accelerate engine wear.

The next time your specifications call for a heavy-duty crankcase oil, we suggest you order Shell Rimula Oil. Write or call today for complete information.

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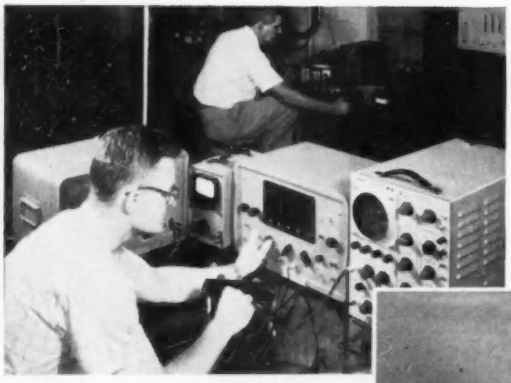
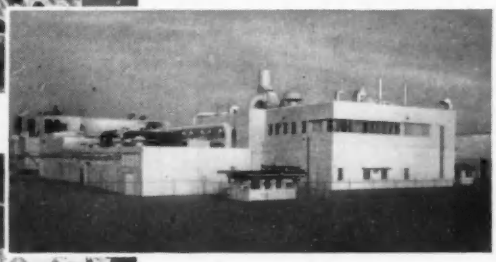
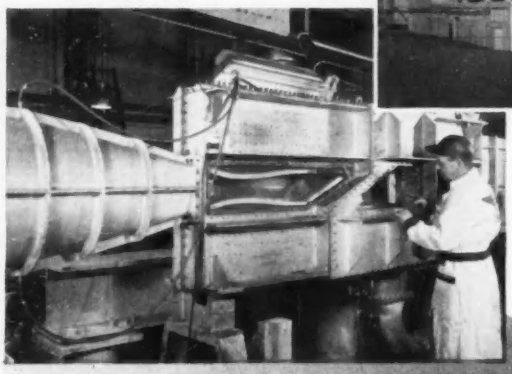
SHELL



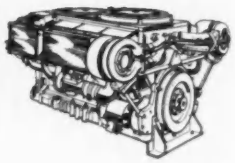


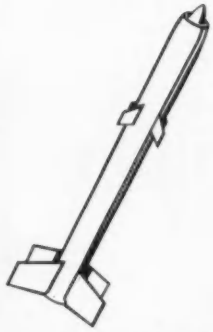


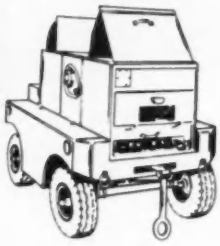
CAE invites your inquiries, and points to past performance as the best indication of what it can do for YOU.

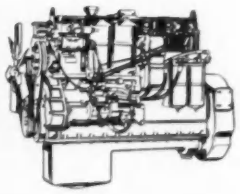
THE R&D CAPABILITIES BEHIND THESE PRODUCTS ARE OPEN TO YOU

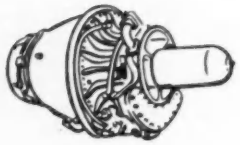
When you entrust a research and development project to CAE, you tap a vast reservoir of specialized experience—enlist technical knowhow of a very special sort. CAE's record of accomplishment is typified by, but by no means limited to, the six units shown at the right. Physical facilities implementing its skills are unsurpassed. They include modern-to-the-minute laboratories—computing, electronic, chemical, metallurgical, fuel metering, stress, and component testing—complete environmental facilities—equipment amply adequate for all phases of the job.











CAE is also equipped for a wide variety of subcontracting operations. Detailed information about its production facilities will be sent on request.

CONTINENTAL AVIATION & ENGINEERING CORPORATION

12700 Kercheval Avenue • Detroit 15, Michigan

"Spring" stays in wheel covers made from Armco Stainless Steel, no matter how often they are put on and taken off. No need to reinforce, either. As formed, they stay strong and rigid.

Impacts that easily damage softer metals won't put stainless out of

Armco Stainless Keeps Its Spring, Helps Keep Dents Out of Wheel Covers

shape. With no chemical surface preparation, wheel covers of Armco Stainless Steel withstand effects of rain, snow, and street chemicals. They are not affected by detergents and white wall cleaners commonly used at home and in car-wash stations.

Lifetime service by millions of stainless wheel covers and hub caps is an excellent example of the contribution of stainless steels to balanced automotive design. Write for detailed information about Armco Stainless Steels. Armco Steel Corporation, 2130 Curtis Street, Middletown, Ohio.

Car owners respect stainless steel. Show them where you use it with STEELMARK labels and tags.

Stainless Steel

ARMCO STEEL

ARMCO

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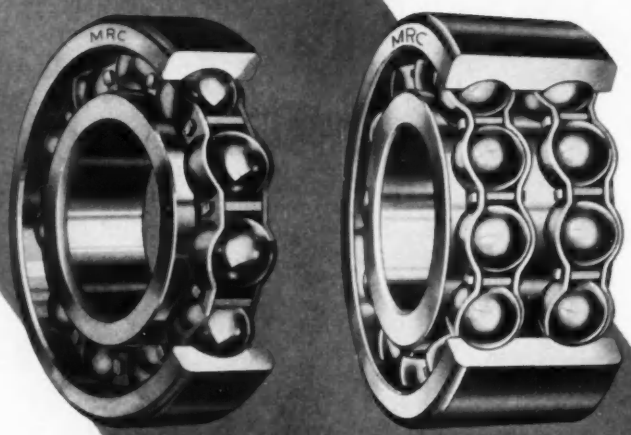
MARLIN-ROCKWELL

RELIABILITY

COUNTS

"SUPER-MAX" Ball Bearings

carry ALL the load... ALL the Way



Providing efficient operation and long life in heavy-duty truck transmissions, tractors, farm machinery... and off-the-road construction equipment.

Backed by 62 Years Experience

Consult OUR Engineering Department on YOUR Bearing Problems

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Take SUSPENSE out of SUSPENSION with LEAF SPRINGS

You can depend on leaf springs!
In addition to prime function, their design characteristics—

- Cushion thrusts of "starts" and "stops"
- Maintain alignment of springs, frame, and axles
- Control load balance
- Minimize sidesway
- Absorb shocks

Simplicity, strength, dependability, and long wear *are inherent in correctly engineered leaf springs.*

DSP *Leaf* SPRINGS

DETROIT STEEL PRODUCTS DIVISION
OF *Fenestra* INCORPORATED
6000 Caniff Avenue, Detroit 12, Michigan

SINCE 1904 — ORIGINAL EQUIPMENT ON CARS, TRUCKS, CABS, BUSES, TRAILERS

After 31 years of continuous growth and

We're changing

The Bendix

To reflect our dynamic growth in such fields as electronics, missiles and space, automotive, weapons systems, computers, machine tools, instrumentation, nuclear technology, hydraulics, meteorology, electrical, marine and others, we are dropping "Aviation" from our corporate name on June 1, 1960. We do not wish to convey the impression that our products and skills are limited to the field of aviation alone, although aviation products accounted for billings of $388,700,000 in 1959.

Today Bendix—through 25 divisions and 16 subsidiary and affiliate companies around the world—serves many fields.

Our success in the rapidly expanding age of aviation has long obscured the fact that the Bendix® automobile starter drive was the company's first major product. Bendix introduced the type of four-wheel brakes that over the years has been used on most makes of cars. Bendix also pioneered automotive power brakes and power steering. Our automotive business in 1959 totaled $114,300,000.

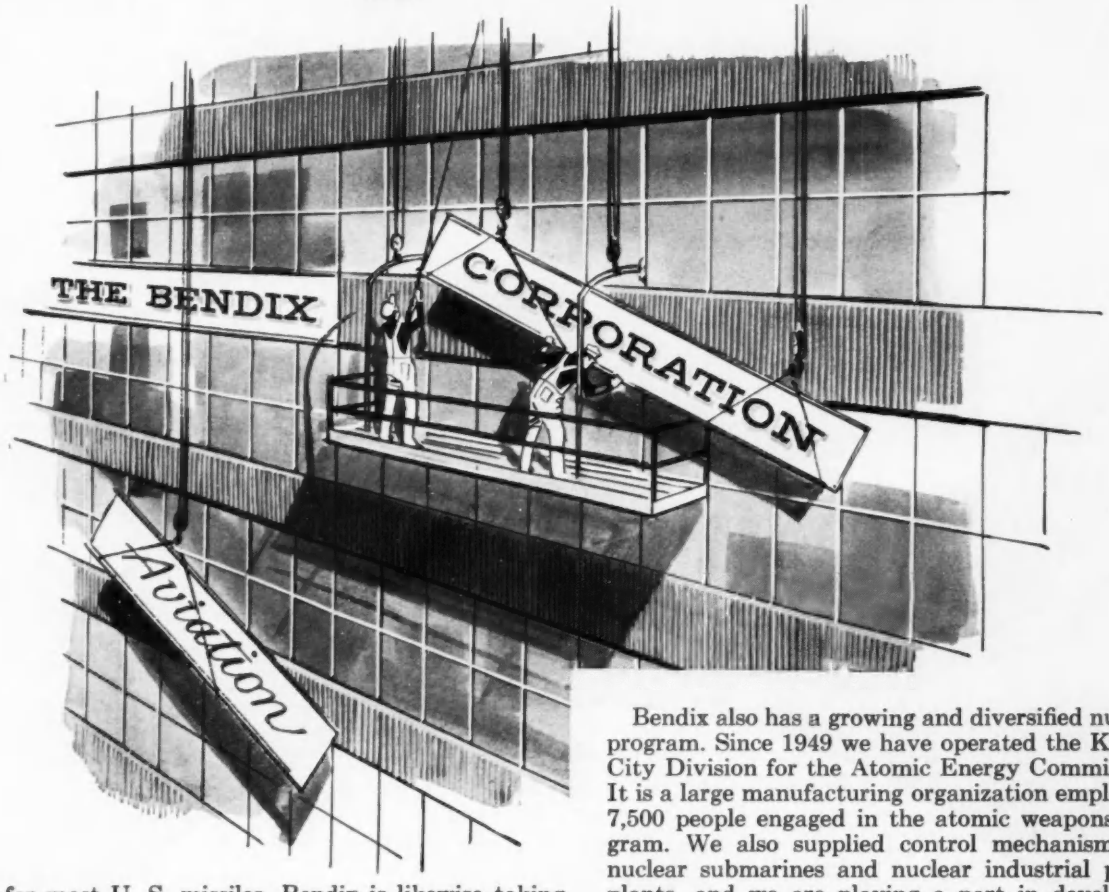
A notable trend in Bendix' recent history is the utilization of electronics in many of our major fields of activity. These range from automobile radios to aircraft and industrial communications and automatic flight controls . . . from electronic computers and data processing to numerical tape control systems for machine tools . . . and from transistors and ship-to-shore telephones to sonic cleaning and undersea sonar detection equipment. Approximately 40% of Bendix products are electronic, including air defense radar which today guards 25 million square miles of the earth's surface.

Missile and space equipment accounted for $103,000,000 of our total business of $689,692,312 in 1959. In addition to being the prime contractor for two important missiles, Talos and Eagle, we are also a supplier of components and sub-systems

diversification as Bendix Aviation Corporation . . .

our name to

Corporation



for most U. S. missiles. Bendix is likewise taking an active part in Project Mercury and in satellite communications. The first is the program to put a man into space. The second will mark a new era in communications by using a satellite in orbit as a relay station for global radio messages between earth stations and aircraft.

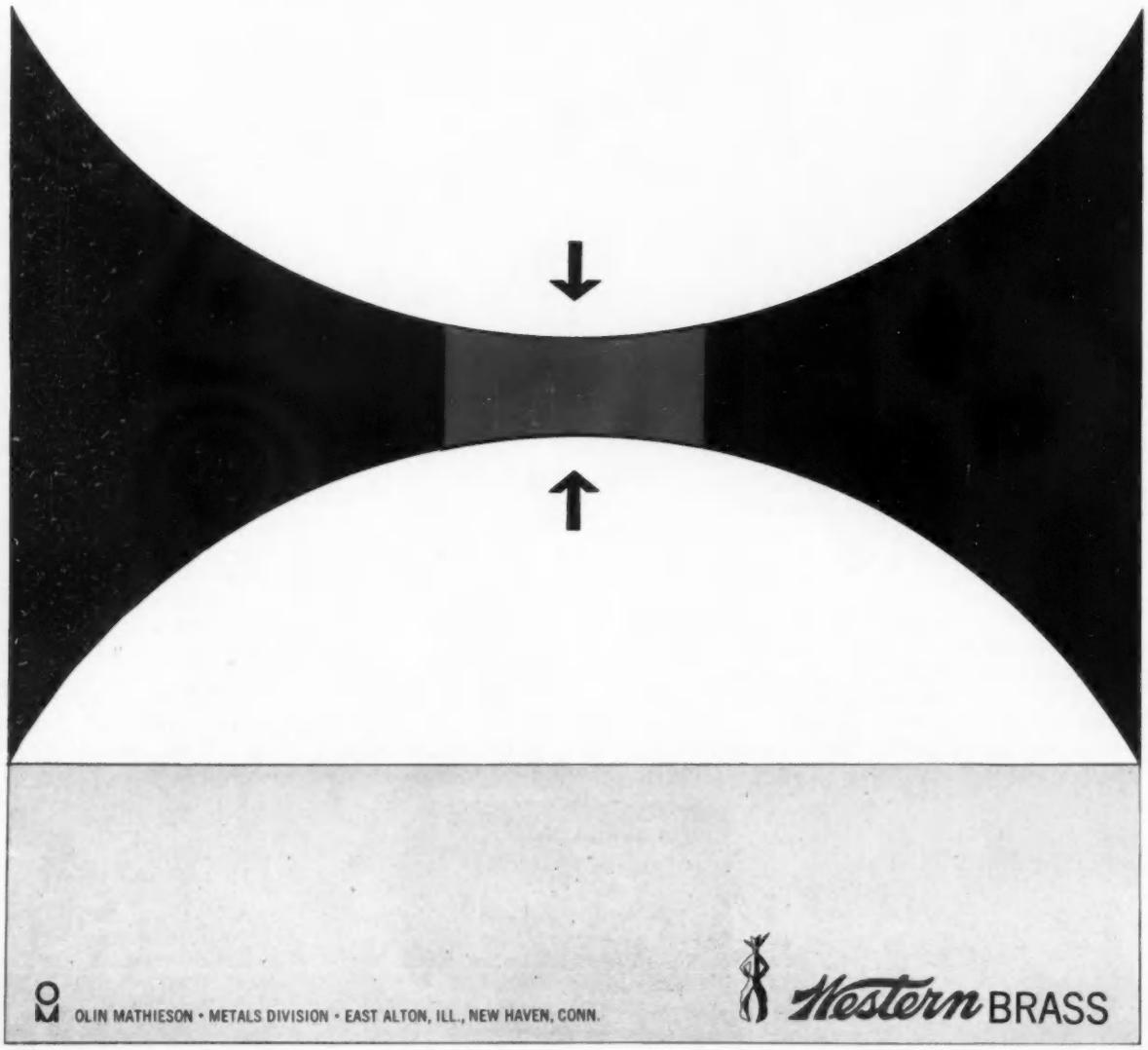
Bendix also has a growing and diversified nuclear program. Since 1949 we have operated the Kansas City Division for the Atomic Energy Commission. It is a large manufacturing organization employing 7,500 people engaged in the atomic weapons program. We also supplied control mechanisms for nuclear submarines and nuclear industrial power plants, and we are playing a part in developing the newest U. S. atomic power plants for aircraft, missiles and space vehicles.

Thus, as we drop "Aviation" from our corporate name, but not from our programs, we face a tomorrow where the range of our opportunities is broadening at a breathtaking rate.

THE Bendix CORPORATION
Fisher Bldg., Detroit 2, Mich.

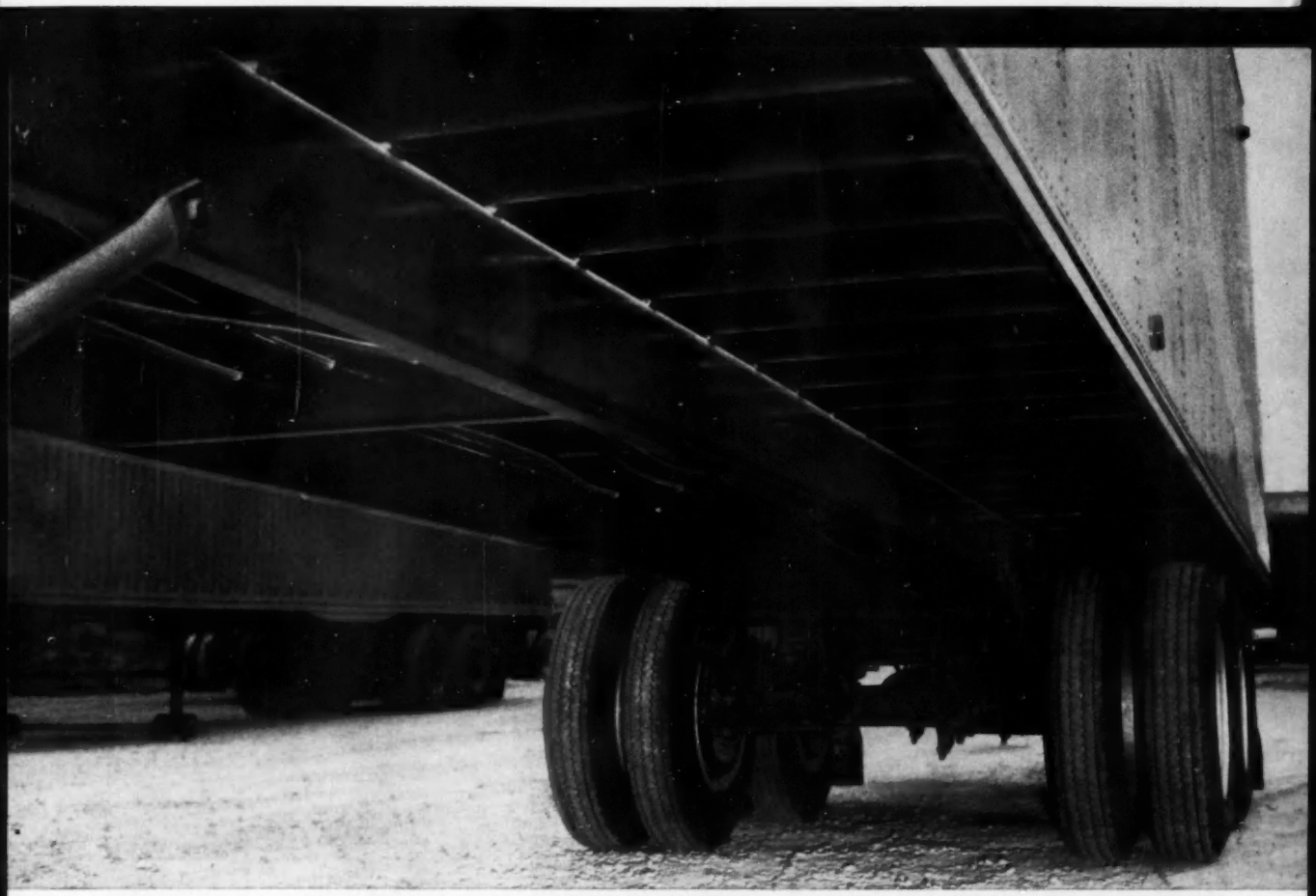
A thousand diversified products

You'll make better connections with Western Brass, because brass is easily–and firmly–welded, brazed, or soldered. With Western Brass you have the added confidence that comes from working with metallurgical specialists who analyze your blueprints to guarantee that you get sheet or strip in the right alloy, temper, grain size, gauge, and finish. You'll make it better with easy-to-bond brass. And you'll make it best with Western Brass—it's "tailor-made" to your individual requirements.



OLIN MATHIESON • METALS DIVISION • EAST ALTON, ILL., NEW HAVEN, CONN.

Western BRASS



Piggyback trailer with underframe of USS High-Strength COR-TEN Steel fabricated by A. O. Smith Corporation. The trailer was built for the Wabash Railroad.

It takes a stiff backbone to ride piggyback

Piggyback trailers must take rough handling and abnormal loading—and while they need to be light for maximum payload, the frame must be extra strong to prevent damage.

To solve this problem, USS COR-TEN High-Strength, Low-Alloy Steel is used for the two 40′ long underframe side rails of these piggyback trailers. The steel was fabricated by the A. O. Smith Corporation, Milwaukee. USS COR-TEN Steel has been used for trailer frames ever since it came out in the early 1930's. It's the best steel on the market for this type of application, especially where you are shooting for low maintenance costs and minimum repair demands. These are made possible because of COR-TEN's high resistance to atmospheric corrosion and additional strength. USS COR-TEN offers a minimum yield point of 50,000 psi compared to 33,000 psi for the steel previously used.

After the last war, the emphasis was on maximum load with minimum truck and trailer weight. But as maintenance and repair costs mounted, many members of the trucking industry realized that only steel could provide the strength necessary to maintain low cost service life for their trailers. USS COR-TEN has solved the problem.

For railroad cars. USS COR-TEN Steel has long been used, not only to reduce dead weight and add strength, but also to provide extra life. Its atmospheric corrosion resistance is 4 to 6 times that of structural carbon steel. Paint lasts considerably longer on COR-TEN Steel and resistance to fatigue and abrasion is high. USS MAN-TEN and TRI-TEN High-Strength Steels are two other brands that can help to reduce weight in your cars. For more information about all three USS High-Strength Steels, write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania, or contact our nearest sales office.

USS, COR-TEN, MAN-TEN and TRI-TEN are registered trademarks

This mark tells you a product is made of modern Steel.

United States Steel Corporation—Pittsburgh
American Steel & Wire—Cleveland
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company
United States Steel

USS

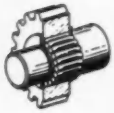
Now you can get highest capacity at lowest cost with Torrington Needle Rollers

A hardened shaft, a hardened housing, and precision Torrington Needle Rollers provide the most economical, highest capacity anti-friction assembly you can obtain.

Six roller end shapes permit design flexibility whether the requirement be maximum effective roller length, proper fillet clearances or greater lip retainment. Torrington Needle Rollers are available in a complete line meeting SAE and AFBMA specifications. Torrington standards for material, heat treat, tolerance and finish of Needle Rollers are the highest in the industry.

Operating results with Needle Rollers depend on careful design of mating parts. Torrington's Engineering Department, with extensive experience in Needle Roller application, will be glad to give you technical advice on your needs.

Full complement of small diameter rollers insures maximum number of contact lines in load zone for high radial capacity in minimum space.



Mounted without races between hardened shaft and hardened housing (RC-60 recommended), Torrington Needle Rollers allow largest possible shaft diameters.

Carefully hardened, ground and lapped high carbon chrome steel makes each Torrington Needle Roller a precision part for long life performance.

Close tolerances are assured by stringent quality controls. Standard OD tolerance is .0002", but Torrington Needle Rollers can be supplied with tolerance of .00005". Tolerance on length depends on end shape.

Fine finish reduces friction to a minimum. Torrington Needle Rollers are usually polished to 4-6 rms, but finishes as fine as 1-3 are available on special order.

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY Torrington, Conn. • South Bend 21, Indiana

SAE JOURNAL

For Sake of Argument

Authority . . .

IT'S AXIOMATIC that authority must start at the top. Lines of operating authority must run downward . . . and the man at the top is the boss. Ergo, the boss exercises the authority.

Like most other pieces of apparently unassailable logic, this one leaks like a sieve when tested as a result-getter. The boss who doesn't substitute the word responsibility for the word "authority" on his organization chart is in for rude awakening. Trouble may not knock at his door next week, but it will get around sooner or later.

"An executive must have the authority to act if he is expected to get a job done," is a commonly heard truism. But he needs wisdom with which to make decisions more than the authority to make them. He needs ability to stimulate and guide a group to want to gain common ends. Authority to *command* a "right face" helps only a little.

The boss needs capacity to spot potentially good ideas, however ineptly communicated by his associates or subordinates. The authority to say "No" can be a hindrance as well as a help.

The boss whose subordinates are always chasing him for decisions, consultations, and assistance isn't running his group, regardless of his organization-chart authority. At best, the group buffets him and each other in a zigzag course toward mutually understood goals. The sum of the buffeting forces — not the designated boss — is exercising the real authority.

The man with capacity to supervise will rarely use the powers given him. Yet, he can't fully exercise his capacity if somebody else has been given the authority. That's why best results rarely come from attempts to bolster a weak executive by a strong assistant. And the ablest supervisors tend to think more of the responsibilities than of the authority given them.

Authority, in brief, is a much overrated, but necessary tool for supervisory achievement.

Norman G. Shidle

This is BENDIX PRODUCTS DIVISION . . .

"LEADER IN BRAKE RESEARCH AND TESTING"

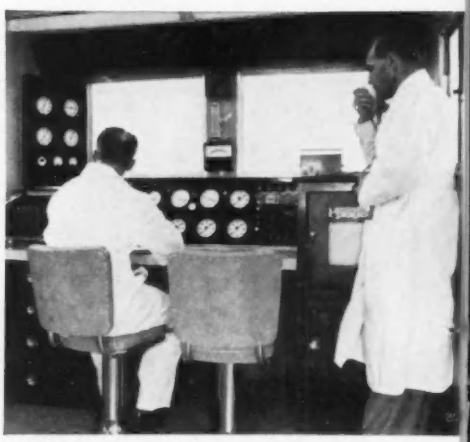
BENDIX MOBILE LABORATORY prepares to take to the highway in the interests of better braking and greater highway safety. Aboard is every scientific instrument needed to measure brake design and performance from every possible angle.

To add even more depth to its research and testing of brakes and power brakes, Bendix Products Division now operates a unique mobile laboratory to gather the most complete braking data ever assembled.

Equipped with the latest in scientific brake test instruments, the Bendix Mobile Laboratory will travel more than 100,000 miles per year making tests under all kinds of driving conditions, over all kinds of roads. It will thoroughly "road check" new brake designs and developments in weather ranging from 30° below zero in Minnesota to 110° in the Arizona desert.

A permanent record of each test run is being maintained for complete study and analysis. Special instruments aboard measure such factors as: speed and stopping distance; temperatures of lining, drums, wheel rims, and hydraulic fluid; speed of brake applications and time lag between trailer and tractor brakes; stroke of master and wheel cylinders; and pressure and displacement input to brakes.

No one else in the world does as much brake research and development work as Bendix—"Brake Headquarters of the World." Why not put this experience to work for you!



TEST RESULTS for each run can be checked visually by Bendix engineers during stops and are also recorded permanently on 25-channel oscillograph for detailed study later. Two-way radio (right) permits conversation with tractor driver and with South Bend headquarters.

PART OF LARGE FLEET of Bendix brake test vehicles operated by Bendix Automotive Engineering, Research, Development and Road Test Departments. Much of work is done in mountainous country. Bendix also maintains large test facility at Jennerstown, Pa.

CAB OF TRACTOR in tractor-trailer combination carries supplementary instrumentation to that in trailer, so that driver can maintain complete control in line with test stop instructions given by engineers in trailer.

BRAKE HEADQUARTERS OF THE WORLD

Bendix PRODUCTS DIVISION
South Bend, IND.

THE Bendix CORPORATION

MOBILE LABORATORY NO. 2 is also used to test brakes and power brakes in all kinds of weather over all kinds of terrain. Trailer interior houses battery of instruments for checking and recording results of test runs.

chips

from SAE meetings, members, and committees

TODAY 44% of the farms in the United States produce 91% of cash farm sales. . . . In this country, one farm worker feeds himself and 23 others with an efficiency which has created the highest living standard in the world. . . . In Russia, 45% of the people still cultivate the land; yet food shortages still are of frequent concern. . . . In China, 80% of the population tills the soil, attempting to feed by primitive means the remaining 20%.

FUEL CELL can potentially produce between two and four times as much power per unit mass of reactants consumed as a good heat engine-generator cycle. This is because the fuel cell is not limited by the Carnot cycle efficiency imposed on all heat engines.

THE BONNEVILLE SALTS FLATS, long the site of automobile speed-record-making, have many characteristics which assist tire performance.

The surface is re-leveled to the curvature of the earth each winter, when the rains are not evaporated as fast as they fall. So, each spring, the course requires only superficial scraping to smooth out small irregularities. . . . The cohesive strength of the salt is less than the adhesion between salt and rubber, so there is practically no abrasion of tire tread. Also, the moisture in salt cools tires and dissipates the heat generated from rapid flexing of the tire structure.

Big *dis*advantage: A variable traction coefficient results from changes in the moisture content. Best traction is obtained in early morning after water level has dropped overnight — and before the sun has had a chance to draw the water back up to the surface.

THE FANTASTIC REALMS OF SOVIET STATISTICS are frequently confusing to the outside world. But it appears that even those they are supposed to enlighten don't always find them understandable. A revealing example is Mr. Khrushchev's recent rebuke of the Secretary of the Byelorussian Communist Party. "I must ask you again," he said. "Maybe I didn't understand you. When you talk about growth in percentages, what does that mean? Did you fulfill your obligations for 1959 or didn't you fulfill them?"

(more chips on following page)

MANY CHANGES HAVE TAKEN PLACE IN STEEL PRICING over the last few years. There are many metallurgical requirements for which cost extras are charged. And, metallurgical properties required of carbon and alloy bar steel contribute 10–20% to the total price.

Table 1 shows typical examples of pricing. It isn't exact but is meant to show the items which have to be considered. A study of Table 1 reveals the need for careful consideration of metallurgical requirements. For example, the hasty specification of a cold-finished alloy bar as an engineering requirement where a hot-rolled alloy bar is adequate would result in a penalty of $2.30 per hundred pounds or 34%. Similarly, ill-considered chemistry, quality, or treatment requirements could result in increased costs.

Table 1
Selected Metallurgical Extras — Carbon and Alloy Bar
(Costs in Dollars per 100 Pounds)

Base Price	
Cold finished alloy bar	9.025
Cold finished carbon bar	7.650
Hot rolled alloy bar	6.725
Hot rolled carbon bar	6.025
Quality Extras	
Aircraft quality	1.95
Cold heading quality	.70
Cold extrusion quality	1.15
Axle shaft quality	.30
Treatment Extras	
Normalized and tempered	2.00
Annealed	1.25
Normalized	1.00
Magnetic tested — ½ in. bar	.80
Machine straightened — ½ in. bar	.75
Pickled — ½ in. bar	
Oiled	.15

Chemical Analysis Extras	
SAE 4027	1.25
SAE 5120	1.30
SAE 8620	2.15
SAE 8615	2.40
SAE 8622	2.05
SAE 5140	1.05
SAE 8640	1.95
SAE 1010	.15
SAE 1019	.40
SAE 1038	.15
SAE 1041	.80
SAE 1043	.35
SAE 1045	.15
SAE 1065	.10
Lead .15 — .35%	1.00
Restricted chemistry	10%*
Restricted hardenability	10%*

* % of base price plus chemical analysis extra.

THE Bendix CORPORATION

chips

from SAE meetings, members, and committees

RESURGENCE OF THE ELECTRIC automobile would certainly eliminate the atmospheric pollution problem, one passenger car engineer opined to some others recently . . . which recalled to a listener the old wheeze about a sure cure for catarrh: "Cut your throat." . . . But few of the group echoed the cynic. Active interest was evident in the ultimate potentials not only of electrics, but of cars powered by gas turbines, fuel cells, and "levitation." . . . All of these, this knowledgable group agreed, must be thoroughly considered in any thoughtful analysis of possible passenger-car-engineering breakthroughs in the '60s. "They all must be considered seriously," as one discusser put it, "even though the ultimate conclusion reached is that no breakthroughs are discernable in this area."

SHOCKS WAVES IN EXPLOSIVE FORMING are being experimentally transmitted by such media as air, water, powdered talc, oil, mercury, sawdust, and plastisol (similar to sponge rubber). Shaped charges and multiple charges are being used.

PRECISION FORGING can pay big dividends. Here's why: An aluminum hand forging for aircraft use weighed 1400 lb; block forging weight was 625 lb; *precision forging cut forged weight to 290 lb.* Finished weight of the forging was 230 lb.

CERAMIC TOOLS may bring savings of as much as 5 to 1, as compared with conventional tools. For some applications, high-speed turning eliminates grinding. Ceramics are particularly effective on hard, abrasive materials, where long cuts are needed.

DIESEL TAXICABS have been in operation in the United States for only about a year and a half. First production model was bought by Charles Ross for the Checker-Detroit fleet in December, 1959. It was a 1959 Plymouth chassis, and carried a Perkins 4-cyl diesel whose bore was 3.5 in.; stroke 5 in.; displacement 192 in.; weight (excluding flywheel) 543 lb. It used No. 2 diesel fuel. Since December, 1959, the Checker-Detroit fleet has added 30 diesel units; has more on order.

Checker-Detroit records show that 17 diesel-powered cabs, which were driven a total of 371,735 miles, used 17,256.5 gal of fuel . . . for an average of 21.5 mpg. (Price of the diesel-option with manual transmission is $795 more than the gasoline-powered cab.)

LOSSES MUST BE CONSIDERED WHEN SIZING AN ACCESSORY POWER SYSTEM. Generation, distribution, and conversion losses may consume as much as one-third of the power delivered by an accessory power unit prime mover at the output shaft. This means that for every 100 w required by a guidance system, the engine must provide 150 w of shaft power. The losses are accounted for by such things as the alternator or hydraulic pumps, distribution equipment, and conversion devices such as inverters.

THE MAGIC CHEMICAL that, when added to oil, will offer the gear designer complete freedom from scuffing, but be absolutely inert in all other respects, has not yet been found. Considerable progress has, however, been made in the control of scuffing with a minimum of harmful side effects since the 1909 Cadillac Instruction Booklet recommended: "The best lubricant for this part [the rear axle] is a mixture of cup-grease and oil, mixed to such a consistency that it will not be so thick that the gears will simply cut a path in it, but be just liquid enough to flow."

ECONOMY OF IMPORTED COMPACTS — even those in the higher horsepower ranges — is often amazing. The 220-hp Jaguar, for example, will give the average user about the same miles per gallon as the 80-hp Corvair, according to John R. Bond, publisher, Road & Track Magazine.

METAL FINISHING EXPENSE accounts for 38% of total cost, according to a recent study by a large automobile manufacturer.

HIGH ENERGY FORMING using TNT dynamite or RDX as explosives may someday be getting some competition from lower energy forming. Olin Mathieson is experimenting with such a process, using powdered gas explosive in electrically operated hydraulic presses. Smokeless black powder gives pressures of 100,000–300,000 psi.

Army Fuel Cell Projects

. . . numbering more than 20, form balanced program aimed to uncover successful applications for future.

Based on paper by **S. J. Magram and B. R. Stein**
Physical Sciences Division, Army Research Office

FUEL CELL ACTIVITIES account for an important share of U. S. Army research and development these days. The fuel cell is one of the few devices which offers promise of exceeding the efficiencies of conventional power units. Claims of successful electrochemical combustion achieving efficiencies greater than the 40% maximum of standard units are currently based on limited laboratory and preliminary prototype models. But the indications from these limited experiments are such as to offer a basis for continuance of a positive outlook.

Some 20-odd tasks comprise the Army fuel cell research and development program which was started three years ago. They are being carried out within Army laboratories, and by contract with universities and industrial organizations.

Signal Corps program

The Signal Corps program is the Army's largest and most varied. Support for fuel cells for space activities comes from this agency.

A 500-W REGENERATIVE HYDROGEN-OXYGEN FUEL CELL of the Bacon type (200 C, 40 atmospheres, potassium hydroxide electrolyte) is being worked on by Pratt & Whitney Division of United Aircraft.

In this project, photovoltaic conversion through "solar cells" will be used to electrolyze water. The hydrogen so produced will be stored to be combined later when no power is available from the solar source. (The first semiannual report on this project has already been issued.)

A SOLAR REGENERATIVE FUEL CELL is under development by the Missiles and Space Division of Lockheed. Two approaches are envisioned:

- *One approach* would involve a chemical system in which the reactants consumed in a fuel cell yield a product which can be decomposed to give the original reactants.
- *A second approach* would use a photochemical regenerative process, thus avoiding the Carnot-cycle limitation of the thermal regenerative. . . . A chemical system will be chosen which will permit the electrochemical reaction to be reversed external to the cell by a photochemical process.

This Lockheed study is concerned mainly with photosensitized oxidation-reduction reactions. The proflavine-ascorbic acid system and thionine-iron systems are now being studied. (The first semiannual report has been issued on this project, which was started in September 1959.)

APPLICATION OF ITS HYDROGEN-OXYGEN CELL is being investigated by General Electric. This cell uses an ion-exchange membrane for the electrolyte for space use. (No results have yet been reported on this contract, which was let in December 1959.)

CONCEPTS FOR NEW SOLAR REGENERATIVE FUEL CELLS are being analyzed, developed, and experimentally tested by Electro-Optical Systems, Inc. This project will study nondissociation-type fuel cells. Such cells are systems which can trap solar energy such as in the heat of solution, heat capacity, and heat of sublimation to supply heat later for thermal regenerative fuel cells.

A THERMALLY REGENERATIVE FUEL CELL is being worked on by the Mine Safety Appliance Research Corp. — since July 1959. A cell using lithium hydride has been constructed. Under consideration also are cadmium hydride and potassium hydride as working media.

The lithium hydride cell has been operated between 570 C and 820 C and has yielded an efficiency of 12%. It is expected that these temperature limits may be extended and other losses reduced to increase the efficiency to about 30%. (Two reports on the progress of this work are already available.)

IN THE SIGNAL CORPS' OWN LABORATORY at Fort Monmouth, N. J., an ambitious program continues to go forward. Included in it are such projects as the following:

- *Regenerative systems employing organic materials with high theoretical capacities* (watt-hours per

Army Fuel Cell Projects

. . . continued

pound) are being investigated. Aromatic nitro and nitroso compounds appear promising. Regeneration of these cathodic materials by a common and readily available oxidizer are also being studied.

- *Study is being made of all possible regenerative systems* capable of using solar, thermal, or nuclear energy for space application.
- *General studies with hydrogen-oxygen fuels* are being carried out, with special consideration given to long cell life and high conversion efficiency.
- *Fuel systems are being investigated which use liquid organic fuels and organic liquids or air as oxidants.* Experimental cells using alcohols and aldehydes have already been set up and are being studied.
- *Study is going forward on ion-exchange membrane systems for hydrogen-oxygen and other fuel combinations.* Use will be made of anion-exchange membranes for study of partial oxidation products of carbonaceous fuels. Studies with alcohols are being carried out and some success has been achieved. . . . The complete electrochemical oxidation of such compounds is quite complicated, since many intermediates must be produced — and each of these intermediates presents special problems of reactivity for further electrochemical combustion.

Ordnance Corps programs

TO PROVIDE A POWERPLANT FOR VEHICULAR PROPULSION is the sole aim of the Ordnance Corps fuel cell program, which is being carried out by the Diamond Ordnance Fuze Laboratories. Two systems are being studied. One is the redox, the other a direct electrode reaction. Each, of course, must employ hydrocarbons as the primary reducing fuel. The contract with Diamond Ordnance Fuze is being divided among the University of Florida, Pennsylvania State University, and General Electric.

The University of Florida program is concerned with the *recovery of bromine,* which was chosen as the best intermediate catholyte, U. of F., is also doing a theoretical study of the operation of a redox cell without separating membrane.

At Penn State, the *chemical regeneration of the anodic element* is being studied. . . . The Diamond Ordnance Fuze Laboratories' *studies on the redox cell* is to include an investigation of the anodic reactant, total cell studies, and electrode polarization and catalysis work.

To pursue a program on the direct fuel electrode system, a contract with California Research Corp. has been made. Here a detailed study will be made of the chemical mechanism and kinetics of electrochemical half-cells using petroleum-derived fuels as the directly oxidizable material. Research will include study of straight-chain, branched-chain, and cyclic alkanes, straight-chain olefins and alcohols.

Electrode material in the California Research studies will be limited initially to catalyzed or treated carbon and nickel, while electrolytes will be considered if thought to be compatible with long-time operation in the presence of the fuels and reaction products. Studies first will be made under ambient operating conditions. The DOF laboratory studies will cover oxidation of methanol in acid medium, which will require an oxygen electrode, which is to be developed at University of Florida.

The future of this program will depend on results of these just-described activities. No one doubts or minimizes the difficulty in reaching the goals set. But practical use of the fuel cell rests on their success.

Corps of Engineers program

A fuel cell program to consider use of readily available and cheap materials to generate electric power has ben established by the Corps of Engineers. With the support of the Ordnance Corps, a contract was let to General Electric to investigate the redox fuel cell. This work was halted, because major difficulties in regeneration of the anolyte intermediate could not be overcome.

Now the GE work is directed toward use of carbonaceous and other fuels in an ion-exchange membrane electrolyte system. In preliminary experiments reaction was achieved, though current densities obtained were small. Construction of a liquid electrolyte cell is to be carried out for use as a test vehicle. Results may lead to development of a modified ion-exchange membrane device. (Progress report No. 8 has been issued on this project.)

Study of low-temperature fuel cells using hydrocarbons and related compounds as fuels is being made under contract by Monsanto Chemical. The fuel electrode will be given major emphasis. Preliminary data on hydrazine shows promising results. Work is being continued with this compound in acid and alkaline media. (The first quarterly progress report has been issued.)

Investigation of a high-temperature molten salt system has been undertaken for the Corps of Engineers by Curtiss-Wright Corp. Aim is to construct a 150-w unit to operate on hydrocarbon gases. The cell electrolyte is a mixture of alkali carbonates. The electrodes are treated stainless steel. (One report has been issued.)

European research participates

Research on a high-temperature molten salt system is being done under a contract between the European Research Office, Department of the Army, and the Central Technical Institute (TNO) of The Hague, Holland. Continuous operation of some cells has exceeded 6 months. At present, different cell designs are being tested, theoretical problems are being studied, and experiments with various fuel mixtures are continuing. (Three quarterly reports have been made.)

This entire Army fuel cell program is still in the research stage. It has not yet reached the developmental stage. The Army believes it to be a balanced program, from which some successful application seems likely.

To order Paper No. 179B . . .
from which material for this article was drawn, see p. 6.

Step Gas Bearings

. . . promising development for aircraft accessory equipment. Support heavy loads under most rigorous conditions and are simple to produce.

Based on paper by

C. R. Adams
Boeing Airplane Co.

STEP GAS BEARINGS raise load carrying capacity and increase service life. They have advantages where conditions to be met are high speeds, high and low temperatures, radiation, or low friction. And because of their ease and simplicity of manufacture they hold great promise for aircraft accessory equipment.

Gas bearings fall into two categories:

1. The self-acting bearing, which depends on the development of a pressure wedge during rotation to support the load. It is similar to a hydrodyamic oil bearing in design and operation.
2. The externally pressurized bearing which has the supporting pressure supplied from an outside source. It can be compared to a hydrostatic oil bearing.

Externally pressurized bearings

Most externally pressurized radial gas bearings have the gas supplied to the bearing through a series of small orifices around the journal periphery at its center (Fig. 1). The gas is throttled through the multiple orifices as it enters the bearing. Pressure buildup around the shaft is determined by eccentricity of the shaft in the journal, since clearance controls the leakage rate. Pressure pockets may be used to increase load-carrying capability, but the added volume of trapped compressible fluid may cause instability.

Boeing's externally pressurized bearing is based on the principle of throttling the gas as it leaves the bearing rather than as it enters. Dams, or steps, machined on either the shaft or the journal, serve as the throttling device (Fig. 2). The step is parallel to the direction of motion and so differs from the Rayleigh step bearing, which has the step perpendicular to the direction of motion.

Pressure distribution in a step bearing and in a stepless bearing is compared in Fig. 3. When there is no step on the shaft or housing, pressure cannot build up under the shaft to produce lift. Leakage at the top of the shaft causes the pressure to drop in an almost straight line from inlet to atmospheric. This pressure acts as a locking force. When there is a step on either shaft or housing, pressure builds up under the shaft and creates a lift. Pressure drops off to atmospheric as the gas flows out the gap at the top of the shaft. Since the flow rate through the gap at the top of the shaft is greater than the flow rate at the bottom, there is a greater pressure drop at the top. The resultant difference in pressure provides the necessary lift to float the shaft.

In the last two years, the possibility of using turbo machinery mounted on gas bearings has been explored by a number of aircraft equipment manufacturers. All applications initially proposed used externally pressurized, multiple-orifice bearings. The pressure source varies from use of engine bleed air, as in the turbonator, to using the gas produced by decomposition of hydrazine in secondary power turbines for missiles. We have placed our experimental efforts on the step bearing concept. Fig. 4 illustrates one of the Boeing turbine step bearing test units. In this unit, pressure which supports the radial load is also used to support thrust loads before it leaks off to the atmosphere.

Importance of design

Gas bearings designs are critical. Manufacturing tolerances, variations in gas supply pressure, temperature variations, and gas contamination must all be considered. Mathematical analysis of bearing capability is valuable, but actual operation will usually demonstrate need for modifications. Here is a typical example:

Theoretical gas consumption of a multiple-orifice bearing designed for an accessory unit turbine was compatible with required unit efficiencies. However, under simulated service conditions, the shaft clearance had to be increased to compensate for thermal expansion. More fuel was then needed to supply

Step Gas Bearings

. . . continued

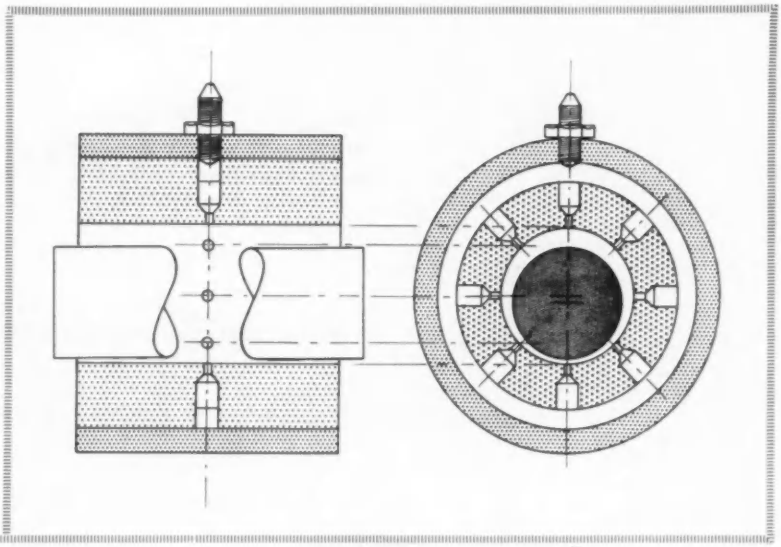


Fig. 1 — Example of externally pressurized, multiple-orifice gas bearing. Gas is throttled through the orifices as it enters the bearing. Pressure buildup is determined by eccentricity of the shaft in the journal since clearance controls leakage.

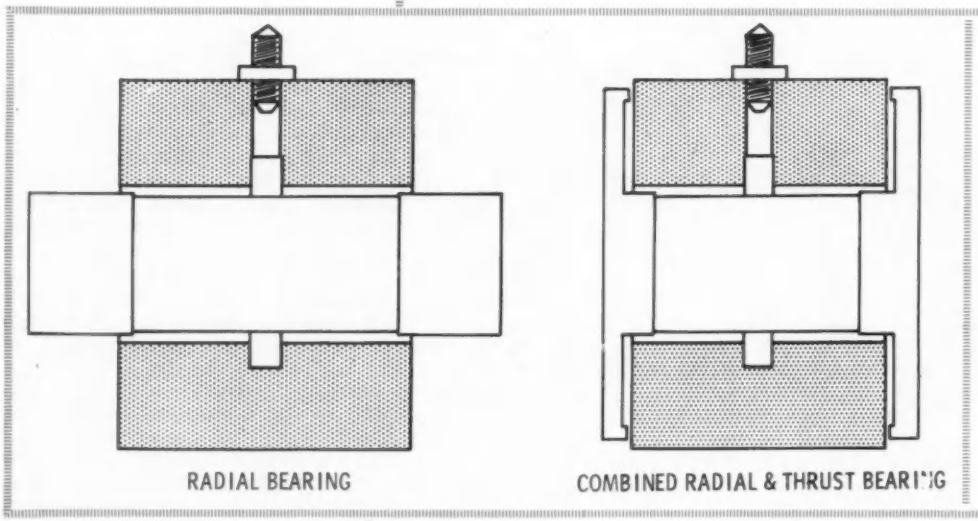


Fig. 2 — Boeing step gas bearings. Dams or steps, machined on either the shaft or journal, throttle the gas as it leaves the bearing rather than on entrance, as with the multiple-orifice type. The step is parallel to the direction of motion.

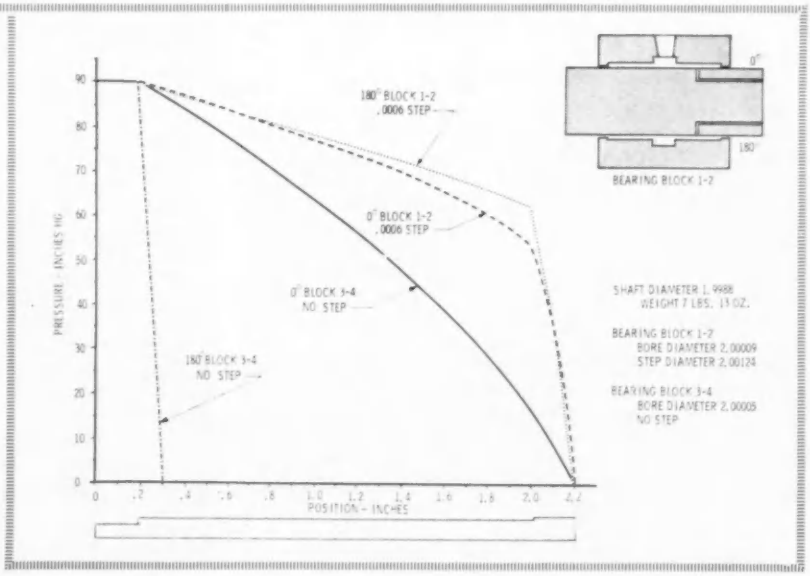


Fig. 3 — Pressure distribution in a step bearing compared with that in a stepless one. In the stepless bearing, pressure acts as a locking force. When there is a step on shaft or housing, pressure builds up under the shaft to create a lift.

decomposed hydrazine gas to the bearing because the leakage rate increased. The design became impractical for long missions, but could still be considered for short flights where the added fuel penalty would be insignificant.

Problems of expansion

Expansion of a shaft due to centrifugal force could reduce bearing clearance at very high speed. However, this will not be a major problem in most applications. We have successfully operated a 2-in. diameter step bearing shaft with 0.0010-in. diametral clearance at 40,000 rpm.

Thermal expansion is not a difficult problem when shaft and housing are made of the same material. In tests to 600 F with a 2-in. diameter shaft, a diametral clearance of 0.002 in. adequately prevented seizure, even during transient conditions when maximum temperatures difference between shaft and housing are met. It may be possible to reduce the diametral clearance to 0.001 in. or less in installations where temperature difference between shaft and housing is kept within 50 F.

Materials compatibility

A number of failures occurred during development because shaft and journal materials would gall when there was metal-to-metal contact. Contacts took place during starts, stops, and sometimes while running, due to unbalanced loads or excessive loads. The contact area of the step bearing is confined to the step, so seizure takes place over a number of revolutions. Gradual seizing means gradual dissipation of inertia forces, which could be an excellent safety feature in some applications.

It is best to use materials with a forgiveness factor to compensate for inadvertent momentary contacts. One of the most satisfactory used at Boeing is a flame-plated, tungsten carbide shaft operating in a Meehanite journal. Other combinations include nitrided-nitraloy shafts in Meehanite or bronze journals.

Step bearings can be modified to permit putting an oil-mist into the gas supply. The oil will leave a thin film on the shaft and journal, which acts as a boundary lubricant and prevents seizure when rubbing occurs.

Production techniques

Load carrying capacity of gas bearings can be affected adversely by misalignment when two or more bearings are used on the same shaft. For this reason, production procedures should be sequenced so that journals can be line bored. Concentricity of bore diameters within 0.0001 in. is required to get uniform load carrying capacity with step bearings. A simple but satisfactory method for getting the necessary concentricity is to complete all grinding operations with a single machine setup. The tolerances which can be allowed for high-speed (20,000–30,000 fpm) bearings will be comparable to those used for ABEC class 5 rolling element bearings. Surface finishes better than 16 RMS are used normally, although a step bearing has been operated at high speeds with a 64-rms surface finish on the journal.

Shaft centers are lapped before setting up for the final grind. Once the shaft has been set up for grinding, all diameters are finished before the shaft is removed from the grinder. This assures concentricity and uniform step height.

A good surface finish is desirable, but it is not as important in the operation of step bearings as maintaining straight bores and parallel surfaces. Lapping or honing of bores for fine finish must be done with extreme care to avoid bellmouth effects. If a bore of 1.0000 in. is bellmouth so that the diameter at the edge of the bore is 1.0002 in., it may have an adverse effect on bearing capacity. The effect is much greater than if the entire bore diameter were increased to the 1.0002 value.

Chemmilling has met with limited success. Cutting the mask with the required precision and obtaining uniform etching rates are most difficult problems. Masks were cut in a lathe, using a special knife in the toolholder. Etching fluid temperature must be carefully controlled to prevent mask shrinkage. We found rotating the shaft during etching to be desirable.

To Order Paper No. 176C . . .
from which material for this article was drawn, see p. 6.

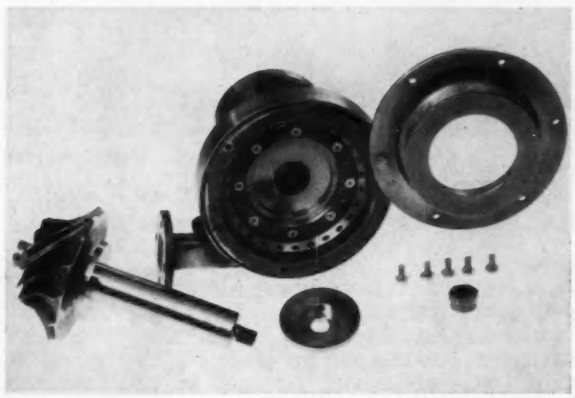


Fig. 4 — Boeing turbine step-bearing test unit. Here the pressure used to support the radial load also supports the thrust loads before it leaks off to the atmosphere.

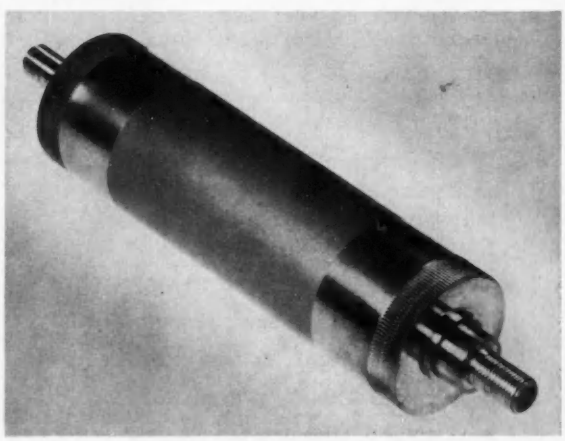


Fig. 5. — Chemmilled shaft. Producing a step by etching is sometimes unsatisfactory because of masking difficulties and variations in the base metal. Rotating shaft during etching is helpful.

Automatic Vehicle Control on

. . . reaches working model stage. Practical now hinges on development of mechanical, electronic

Based on paper by

Harold M. Morrison, Albert F. Welch, and Eugene A. Hanysz

General Motors Corp.

AN AUTOMATIC vehicle control system, known as the GMR Auto-Control, has been developed to increase highway safety as well as highway capacity. It has reached the stage of being embodied in a 1/40-scale model, designed so as to accommodate both automatically and manually controlled cars on a limited access highway.

The essential features of the control system are shown in Fig. 1. The two counterclockwise lanes are equipped for vehicle operation. The right-hand lane is a manual control lane; the left lane has sensing and control wiring for complete automatic operation of scale model buses. The lanes are divided into blocks representing 200 ft of actual highway; the entire model highway simulates a length of 6/10 mile. The block system provides a means for detection of obstacles and speed control. Warning lights tell the manual driver when to use the automatic lane for passing.

THE dream of safer, more efficient traffic, at least on limited-access highways, approaches reality with the GMR Auto-Control System.

It is designed to do four things:

- ► Keep vehicles in their proper path.
- ► Detect obstacles in that path.
- ► Regulate speed to prevent collision.
- ► Control the passing of vehicles.

Car and road control equipment

The control equipment has been divided between the car and the road. Transition from manual to automatic control would be easier if all the control equipment were centered in the car. Then, if none were required in the road, the system could be used on existing road systems. However, this arrangement has shortcomings, particularly with respect to sensing all the information to regulate speed and direction from the vehicle itself.

All the transistorized electronics sufficient to sense the input signals and provide controls for the power systems of a full-scale car are mounted in the model on two insulating boards, which also serve as a frame for the mechanism (Fig. 2). An electric torque motor turns the front wheels to provide steering connections. A silver-zinc battery supplies power for the electronics and the drive and steering motors.

Steering and speed control

The steering control element in the model highway is in the form of a criss-crossed wire forming essentially two parallel wires embedded in the pavement down the center of the lane. An alternating current of about 50 kc in the wire generates a magnetic field along its entire path. The same wire is

Highways

application

reliable

equipment.

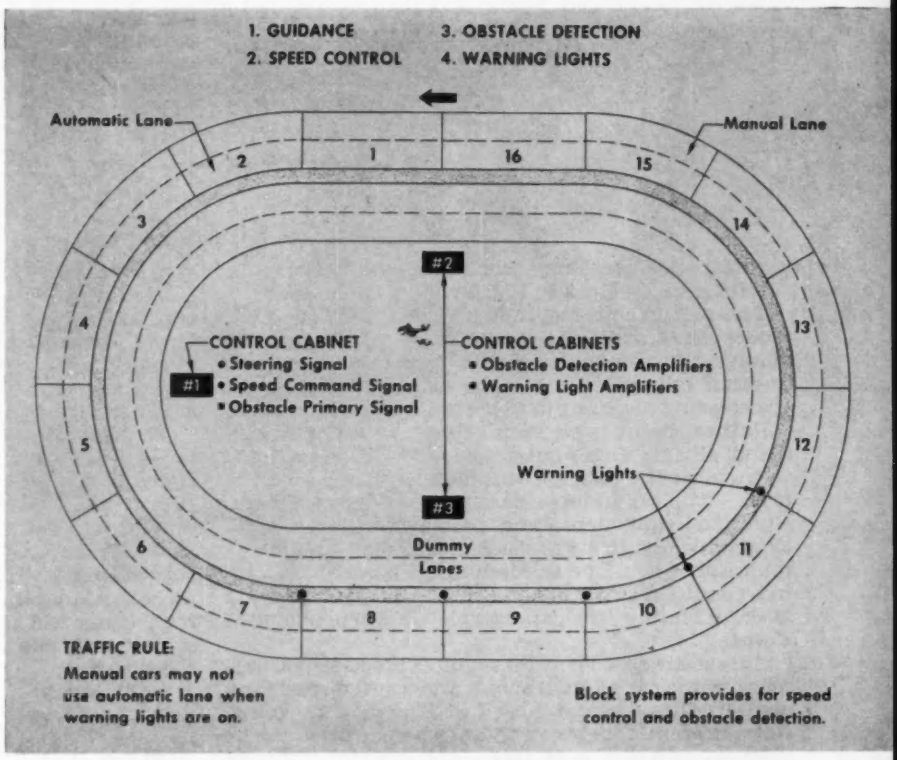


Fig. 1 — **Highway layout (1/40-scale model) of GMR Auto-Control System.** Control mechanism is divided between highway and vehicle and is designed for both automatic and manual driving on a limited access highway.

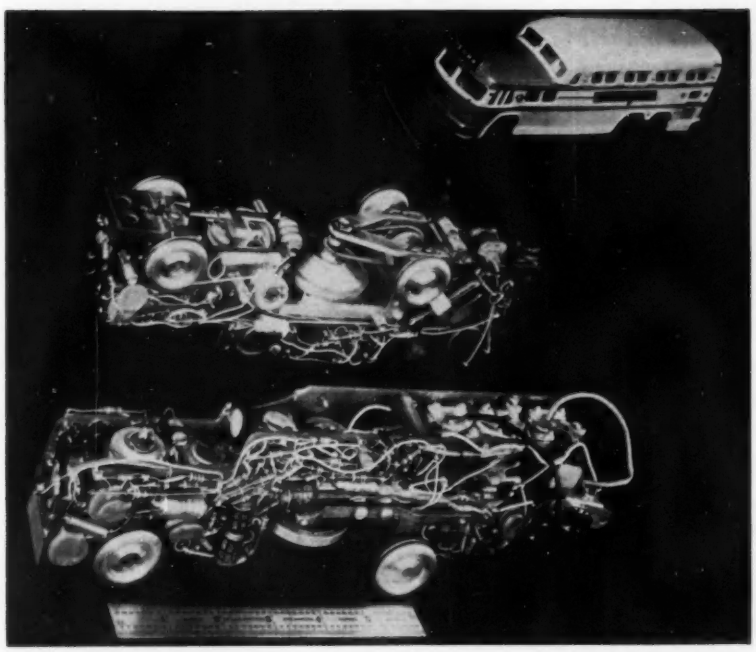


Fig. 2 — **Top and bottom view of the 1/40-scale** bus carrying all the transistorized electronics required for a full-scale car using this automatic control system.

Automatic Vehicle Control on Highways

. . . continued

used for speed sensing. Control wiring is shown in full for a single block in Fig. 3.

Two pickup coils mounted on the underside of the model car straddle the criss-cross wire. Changes in voltage between the two coils, determined by their position relative to the cable, automatically adjust the steering mechanism to keep the car on course.

Rather than permit each vehicle to select its own speed, all cars under automatic control are expected to travel at the road speed limit, arbitrarily set at 60 mph. This eliminates passing to a great extent, simplifies equipment, and prevents delays due to slow vehicles. In a full-scale application, any maximum speed could be selected and varied to fit driving conditions. Provisions in the model impose a 30-mph limit or stop cars completely when 60 mph is unsafe.

Automatic speed control requires precise measurement of the car's actual speed, and a speed command signal telling the car how fast it should be going. Any differential between these two quantities can be used to initiate automatic adjustment of speed through control of accelerator and brakes.

The criss-crossed wire is installed so that its two branches cross at equally spaced intervals. The voltage induced in the car's speed measurement pickup coil becomes zero midway between each crossing of the wire, thus providing a marker that can be sensed by a pickup coil and counted. The car measures its own speed precisely by a count of the number of voltage nulls passed per second. Cross spacing selection makes 1 cps equal 1 mph both in the model and on a full-scale road.

Speed command signal

A wire, parallel with and centered in the criss-crossed wire, provides a speed command signal which is picked up by another coil. The wire carries a signal of about 90 kc modulated by either of two frequencies to provide the 60- and 30-mph speed command signals. The signal is interrupted for zero command speed. Command speed is determined by obstacle detectors in adjacent blocks. When the car speed is over or under the command speed, an error signal is created proportional to the difference between the frequency of the command speed modulating signal and the number of voltage nulls per second from the criss-crossed wire. The error signal regulates the current to a small electric motor in the model, causing the car's speed to become equal to the road command speed. In a full-scale vehicle the signal would control the accelerator and brake pedal combination.

Obstacle detection

Vehicles and other metallic objects are detected electromagnetically in the automatic lane alone. Embedded below the surface of each block (200 ft of actual highway) are four obstacle detector coils

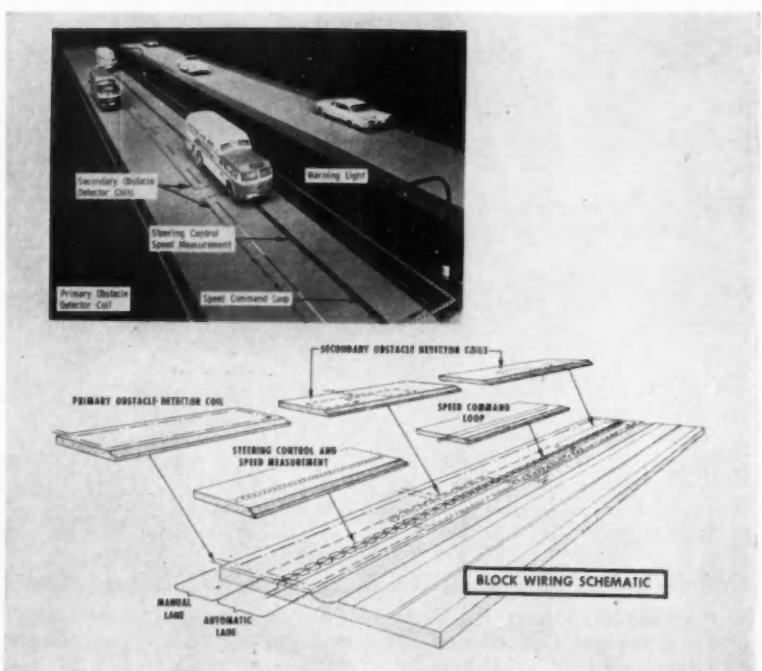


Fig. 3 — **Layout of one block of the automatic highway** showing the control wires for steering and speed, and obstacle detection. A block represents 200 ft of actual highway.

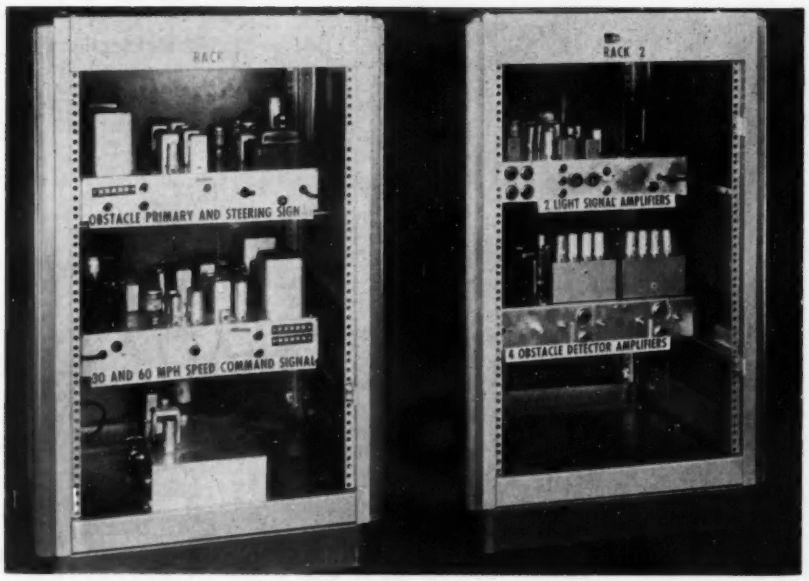

RACK 1
OBSTACLE PRIMARY AND STEERING SIGN
30 AND 60 MPH SPEED COMMAND SIGNAL
RACK 2
2 LIGHT SIGNAL AMPLIFIERS
4 OBSTACLE DETECTOR AMPLIFIERS

Fig. 4 — **These two cabinets** contain all the road electronic equipment needed for 400 ft of controlled highway, with the exception of the primary guidance signal. No attempt has been made to reduce the size of this equipment.

(secondary) and a larger coil (primary) which encloses the secondary (Fig. 3). The four secondary coils are connected in pairs with two coils in each pair connected in opposition and alternately spaced with the two coils of the other pair. Metal objects in the detector section have eddy currents induced by the alternating field produced by the primary coil which is energized with alternating current. This causes a disturbance of the magnetic field through the secondary coil over which the obstacle is located and the resulting unbalance in induced voltage provides a reliable indication of the obstacle, whether moving or stationary. The time interval between detection at successive secondaries is also used to give an approximate indication of the vehicle speed. Its presence and speed regulate the command speed in the following blocks.

A car traveling over 30 mph, for example, causes a 30-mph speed command signal to exist in the first block to the rear and a 60-mph signal in the second block to the rear. A car going 30 mph or below raises a zero speed signal in the first block to the rear and a 30-mph signal in the second block.

The driver is expected to use manual control when fixed obstacles are met, and the manual lane can be used for getting around obstacles before resuming automatic operation. In fact, if an automatic vehicle is stopped for an obstacle it becomes an obstacle for itself and cannot continue automatically even if the obstacle is removed. To resume automatic control, the driver must accelerate the car manually over 30 mph and then flip on the auto-control switch.

Manual car operation

Manually controlled cars would travel in the right-hand lane as usual. Use of the left lane for passing is regulated in the model road by traffic signals which indicate the presence of an automatic car in the immediate vicinity. Warning lights are turned on by a 2-kc signal from a coil on the automatic car to the speed command coil in the road. These lights "travel" along with the car to warn manually operated cars that the automatic lane is in use. One light would handle a 200-ft block. These lights would give smooth operation in the automatic lane, but should a manual car enter against the signal it would be detected as an obstacle and cause the following automatic cars to come to a stop.

Fig. 4 shows the electronic equipment racks used with the road model. They are representative of functionally full-scale equipment, since no effort was made to reduce the size of this prototype. The two cabinets provide all the electronics needed for 400 ft (2 blocks) of lane with the exception of the primary guidance signal. This signal can be supplied to many blocks by a simple single oscillator. The equipment could be installed below grade and run from batteries floated on a charger to increase reliability.

Built-in reliability

Redundancy has been used in the model to increase steering signal reliability. The speed command wire as well as the crossed guidance wire signal may be used for this purpose. Automatic switchover would occur in the full-scale installation in the event of loss of primary system signal. Protection has also been provided in the event of speed command signal failure — the loss would be equivalent to commanding zero speed and vehicles would stop until manual control is assumed.

To Order Paper No. 151A . . .
from which material for this article was drawn, see p. 6.

Abridgment of an
SAE Met Section Paper

How Soviet jets COMPARE with other jets of the world

Based on paper by

S. D. Browne
Browne & Shaw Co., Inc.

SOVIET jet transports are compared with other well-known jets, in the accompanying table.

The first Soviet jet to appear on the World air transport scene was the TU-104. This 50-passenger twin turbojet was a modification of the Tupolev-16 (Badger) medium bomber. It used the Mikulin M-209 (AM-3) axial-flow turbojets, estimated to have 15,000–17,000-lb thrust. According to the Aeroflot journal *Grazhdanskaya Aviatsia*, the TU-104 and its modified versions began regular service on June 15, 1956, and since then have been extended to most of the long-range international and internal lines of Aeroflot. The TU-104A version is the same aircraft with 70 seats (16 first class and 54 tourist). It has an improved engine, the Zubets RD3M (redesign of the M-209) with 20,950-lb static thrust. In addition to carrying a greater payload, it is claimed to be more economical than the original TU-104. It is possible that the TU-104 has been largely withdrawn from regular service.

In September 1958, the TU-104B was announced, to carry 100 passengers, two tons of baggage, and two tons of freight at a cruising speed of 500–560 mph at 32,800–40,000-ft altitude. Although the powerplants and basic components of the aircraft remain unchanged, by Soviet definition the aircraft became more economical by re-arrangement of the interior to accommodate the increase of 30 passengers. It should not be assumed that this higher-density seating arrangement means that the aircraft is designated for use on short-haul, because the TU-104B has been assigned to the longest internal route of the Soviet Union, that is, Leningrad to Vladivostok.

Although there had been extensive mention of the TU-114 4-turboprop airliner in the Soviet and satellite press as early as the fall of 1957, its official debut to the western world was not until June 1959, when one brought Frol Kozlov to New York.

TU-114D is the long-range version, designed to carry 120 passengers for such long nonstop flights as Moscow–New York, Moscow–Peking, Moscow–Tokyo, or for long internal runs such as Moscow to Magadan, Moscow–Vladivostok, Moscow–Petropavlovsk/Kamchatka. There is to be a 170-seat version for shorter internal routes and, finally, a 220-seat version designated as "short-range tourist" for high-density runs such as Moscow–Sochi and Moscow–Simferopol, where the stated objective is to reduce air fares to the level of rail travel within the Soviet Union. This aircraft does not as yet appear to be in regular scheduled airline operation, although it has been used for the propaganda transportation of important government officials and for a variety of "record-breaking" flights, mostly in terms of test flights not as yet flown by competing aircraft.

Already in Aeroflot service and replacing IL-14 and other piston-engine transport aircraft are the IL-18 and the AN-10 turboprop transport aircraft.

TURBOJETS

TYPE	DESIGN/CONSTRUCTOR GROUP		NO. ENGINES	THRUST OR E.S.H.P.	DIMENSIONS			WEIGHT			SPEED		RANGE MILES	SERVICE CEILING FEET	CREW	PASSENGERS
	AIRFRAME	ENGINES			SPAN FT. IN.	LENGTH FT. IN.	HEIGHT FT. IN.	EMPTY LBS.	PAYLOAD LBS.	GROSS LBS.	MAXIMUM MPH	CRUISE MPH				
TYPE 133	VEB EAST GERMANY	PIRNA 014 A-1	4	S/L 7,260#	86' 8"	107'	28' 6"	64,100#	20,500#	T.O. 105,500# Ldg. 79,300#	571	35,000' .497	1,083	35,400'	4 + St.	48-58-73
CARAVELLE	SUD	ROLLS ROYCE MK. 527	2	11,400#	112' 6"	104' 10"	28' 7"	52,030#	18,453#	T.O. 99,208# Ldg. 94,468#		32,800' .481	1,370		2-3 + St.	64-80
TU-104	TUPOLEV 1954-55	MIKULIN AM-3 (M-209)	2	S/L 14,850#	114' 10"	121' 5"	39' 4½"	42,880#		121,250# Max. 154,325#	559	33,800' .515	2,000	Max. 39,360'	6	50
TU-104A	TUPOLEV 1957	ZUBETS RD3M (M-3DR)	2	20,950#	114' 10"	121' 5"	39' 4½"		Max. 19,842#	Max. 164,250#	620	497	Cr. 1865	32,800	6	70
TU-104B	TUPOLEV 1957	ZUBETS RD3M (M-209)	2	20,950#	114' 10"	125' 4"	39' 4½"		Max. 26,455#						6	100
COMET 4C	DE HAVILLAND	ROLLS ROYCE AVON	4	10,500#	114' 10"	118'	29' 6"		24,610#	T.O. 162,000# Ldg. 118,500#		33,000' .500	2,820		4 + St.	60-81
880	CONVAIR	GE CJ-805-3	4	11,200#	120'	129' 4"	36' 4"	84,700#	23,150–26,780	T.O. 184,500# Ldg. 132,800#		615	3,900	40,000'	3 + 3	88-110
600	CONVAIR	GE CJ-805-21 DUCTED-FAN	4	16,100#	120'	139' 5"	39' 7"	110,820#	25,120#–29,245#	T.O. 244,200# Ldg. 180,000#		635	4,600	40,000'	3 + 3	96-128
707-320	BOEING	P AND W JT4A-9	4	16,800#	142' 5"	152' 11"	42' 5"	125,200#	57,100#	T.O. 312,000# Ldg. 207,000 #	23,500' .610	40,000' .530	5,650	42,000'	4 + St.	131-171-183
720B	BOEING	P AND W JT3D-1 TURBOFAN	4	17,000#	130' 10"	136' 2"	41' 6"	105,500#	38,200#	T.O. 229,000# Ldg. 175,000#	22,500' .615	40,000' .530	4,360	42,000'	4 + St.	106-142-151
DC-8	DOUGLAS	P AND W JT4A-3	4	15,800#	142' 5"	150' 8"	42' 4"	124,418#	41,000#	T.O. 310,000# Ldg. 199,500#	600	600	5,000	40,000'	3 + St.	118-132-144-168-176

TURBOPROPS

VISCOUNT 840	VICKERS	ROLLS ROYCE DART (MK. 541)	4	2,350	93' 8½"	85'	27' 9"	41,276#	15,054#	T.O. 72,500# Ldg. 62,500#		400	1200-1650		3	52-65-75
AW. 650	ARMSTRONG WHITWORTH	ROLLS ROYCE DART (MK. 526)	4	1,910	115'	86' 9"	27'	46,000#	28,000#	82,000#		276-296	1600-2000	22,600'	2-3	77
ELECTRA 188C	LOCKHEED	ALLISON 501-D13	4	3,750	99'	104' 6½"	32' 1"	56,000#	21,638# Max. 26,500#	T.O. 116,000# Ldg. 95,650#	12,000' .448	33,000' .405	2770-3,460	27,000'	5	66-99
VANGUARD 953	VICKERS	ROLLS ROYCE TYNE (MK. 512)	4	5,020	118'	122' 10½"	35'	78,575#	29,000#	T.O. 141,000# Ldg. 121,000#		425	1750-2340			76-97-120-139
CL-44	CANADAIR	ROLLS ROYCE TYNE 12	4	5,730	142' 4"	136' 7"	36' 8"	87,226#	66,000# CARGO	T.O. 205,000# Ldg. 165,000#		390	3,300	20,000'	3 or 4	160-172
IL-18	ILYUSHIN 1957-59	KUZNETSOV NK-4 IVCHENKO AI-20	4 4	4,000 4,000	122' 8½" 122' 8½"	117' 117'	33' 5" 33' 5"	61,730# 61,730#	30,865# 26,455#	119,000# 127,870#		26,250' .404 26,250' .404	1250-3000	32,000' Max. 43,550'	5 5	98 75
AN-10	ANTONOV 1955-57	KUZNETSOV NK-4	4	4,000	124' 7"	114' 10"	32' 1"								5	84
AN-10A	ANTONOV 1958	IVCHENKO AI-20	4	4,000	124' 7"	121' 5"	32' 1"		26,450#	110,200#		370-390	Max. 1,860	Cr. 19,700–Max. 32,800'	5	100
AN-16	ANTONOV	IVCHENKO AI-20	4	4,000	124' 7"	131' 3"	32' 1"								5	130
TU-114	TUPOLEV 1957	KUZNETSOV NK-012M OR 022K	4	12,000	177' 2"	154' 10"	38' 8½"	188,274#	39,683#	T.O. 413,917# Ldg. 275,573#		32,800' .531 29,200' .565	6,214-9,010	34,120'	10-15	120-170-220

Turbojet and Turboprop Transport Aircraft of the World Compared

The Ilyushin 18, a 4-engine low-wing turboprop transport was first extensively described in September 1957 as being projected for both 76- and 100-passenger versions. The aircraft was tested throughout the fall and winter of 1957 and spring of 1958.

Both the Ilyushin 18 and the Antonov 10 were originally designed with four Kuznetsov 4000-eshp turboprop engines. Later production aircraft of both designs are powered by the Ivchenko AI-20 engine, which has the same rating but is claimed to be more economical.

The Antonov 10 is a high-wing 4-turboprop passenger aircraft designed for 84 passengers. A subsequent version — the AN-10A — is designed to take 100 passengers. The Antonov 10 has gone into service on Aeroflot routes somewhat behind the introduction of the Ilyushin 18. It appears to be designed primarily for service on unpaved runways of unimproved airports in the Soviet Union, although the Ilyushin 18 and the TU-114 have this consideration very much in evidence in the design of their gear and landing characteristics.

The AN-16 is a 130-passenger version of the AN-10. It is basically a modification of the AN-10A and has the same powerplants (AI-20). The original AN-10 was lengthened from 114 ft, 10 in. to 121 ft, 5 in. to accommodate the increase in passenger capacity from 84 to 100. Similarly, the AN-16 fuselage has been lengthened to 131 ft, 3 in. to carry a total of 130 passengers. All three aircraft normally have a crew of five.

To order Paper No. S235 . . .
from which material for this article was drawn, see p. 6.

Computers analyze drivetrain

Based on paper by

S. E. Staffeld

Chrysler Corp.

COMPUTER ANALYSIS OF AUTOMOTIVE DRIVETRAINS has increased the ability of engineers to deal with the many, and increasing, combinations of powerplants, transmission extensions, and propshafts. In advanced design programs, the computations have been helpful in picking out the driveline lineups most likely to have vibration problems so that they might be scheduled for early test and allowed maximum lead time for development. Direct applications have been made — destructively high stresses reduced by modifications to increase the tuning ratio — but the benefits of being able to rapidly see the effect of the variation of a length, weight, or stiffness and of knowing what phenomena can and can't be explained by the given set of assumptions, are probably of the greatest value.

All front-engine American automobiles use a drivetrain with certain basic features (Fig. 1). The engine transmits its power through a clutch or torque converter, a transmission and transmission extension to the propshaft, the propshaft to the axle carrier. Power is transferred through universal joints at each end of the propshaft. Flexibility in the torque converter housing, transmission extension, and propshaft gives rise to two types of vibration phenomena.

Unbalance in the propshaft excites vibration of the drivetrain system at a first order frequency, that is, one cycle of vibration for each revolution of the shaft. The unbalance may be anywhere in the shaft, although it is found that unbalance in the center is more serious than at one of the end flanges. This effect occurs with most drivelines at high speeds, in some cases beyond the top speed of the car. This effect can be very serious. An unbalance can rapidly cause failure of the propshaft, transmission extension, or torque converter housing at the critical speed.

In addition, the universal joints generate second order forces and moments, the magnitudes of which are proportional to joint angularity. Being second order, that is one vibration cycle for each one-half propshaft revolution, vibrations caused by these forces take place at car speeds in the normal driving range. The problem here is not stress but noise, vibrations being transmitted through the engine mounts and suspension to the body shell. There are usually at least four of these periods, of which and without any obvious pattern some are louder than others.

It was usual to think of these phenomena in terms of the so-called prop critical speed, the resonant frequency of the propshaft with both ends attached to fixed universal joints. This is the vibration frequency of the shaft as it is mounted in a balance machine. It is easy to measure and to relate to length, diameter, and metal thickness. But, this approach didn't lead to much more in the way of prediction than to expect that all driveline frequencies would rise and fall with that of the prop.

There was, of course, a considerable body of experience to draw on in formulating and developing a driveline design but there were still surprises. An analytical approach, made possible by the digital computer, has been able to reduce some of the surprises and to make predictions of design value.

Computer analysis

The aim of computer analysis was to take into account the important facts neglected by the prop critical speed approach. It was clear that flexibility in the powerplant and in the axle carrier were important and that, where possible, the input to these components should be derived from drawings and experimental data with a minimum of manual reduction. It was known that the principal axes of mass and of flexibility were close to horizontal and vertical in all components so that vibration could be considered as the vector sum of two independent planar vibrations. Damping, although significant, was neglected with the feeling that it would not greatly affect resonant frequency values and their mode shapes.

The powerplant and the propshaft were considered as nonuniform beams — mass and flexibility varying along their lengths. These nonuniform beams are considered to be composed of increments consisting of a flexible weightless beam with mass and moment of inertia concentrated at one end. Since

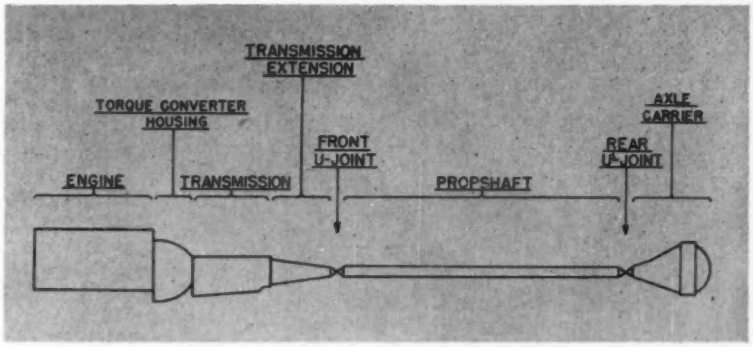


Fig. 1 — Drivetrain arrangement of typical American front-engine car.

the increments may be small and the mass distributed as continuously as desired, no inaccuracies are introduced. Considering the increment to be part of a beam executing linear planar vibration, we can express the four variables, displacement amplitude, angular amplitude, shear force amplitude, and bending moment amplitude, at one end in terms of the other end from its flexibility, length, mass, and moment of inertia. This is expressed in terms of four simultaneous equations. With such a set of equations for each segment into which the beam is divided, it is theoretically possible to express the variables relating to one end of the entire beam in terms of the other end.

Of course, with many increments, to express one end of the beam in terms of the other algebraically would be extremely laborious, and even numerically requires much computation. This, then, is where the digital computer comes in.

A scheme is devised where the computer operates on the constants (flexibility, length, and such) of the first increment to form the coefficients of its simultaneous equations; stores them; forms the coefficients of the second; operates on those of the first to form a new set which relates the left end of the first increment with the right end of the second; forms the third set; forms a new set relating the left end of the first increment with the right end of the third increment; and so on until the last segment of the beam is reached and we have one end of the complete beam in terms of the other.

This gives us four simultaneous equations in eight variables. To solve these equations we will need four more equations which will constitute the boundary conditions. In the case of the powerplant, both shear and bending moment are zero at the front end because it is not connected to anything. At the rear end, bending moment must be zero because of the universal joint. If we then make the amplitude of the shear force arbitrarily equal to + 1000 lb, all the varibles may be solved. This process is repeated for each frequency.

For the condition of horizontal vibration, the axle carrier may be considered as perfectly rigid and thus the displacement amplitude of its nose is zero. Therefore, for the right end of the propshaft, the displacement and the bending moment (because

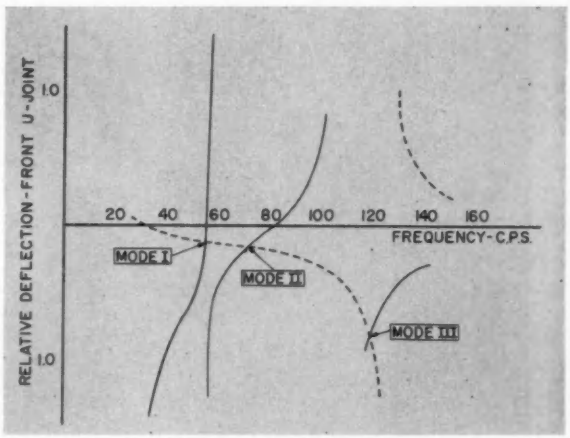


Fig. 2 — Plot to determine resonant frequencies.

of the universal joint) are zero. At the left end the bending moment is zero and we set the shear equal to –1000 lb.

The amplitude of the powerplant and propshaft at the first universal joint are plotted against frequency on a graph. The points where the curves intersect will be the frequencies where the prop and powerplant match in amplitude. Since this is the true final boundary condition for both, it is the frequency at which they resonate together. The choice of any arbitrary force would result in the same frequencies. Since damping hasn't been considered, the amplitudes of the crossing points have no meaning.

In one sense, this is nothing more than a graphical solution of two equations, one relating force and displacement at the end of the transmission extension and the other relating force and displacement at the front end of the propshaft. This all could have been done on a computer with the output as resonant frequencies, but the graphical method helps contribute to understanding the phenomena. Under the prop critical speed theory it is assumed that the powerplant is infinitely stiff and massive. If this were so, the engine curve on the drivetrain resonance curve would be a horizontal line through

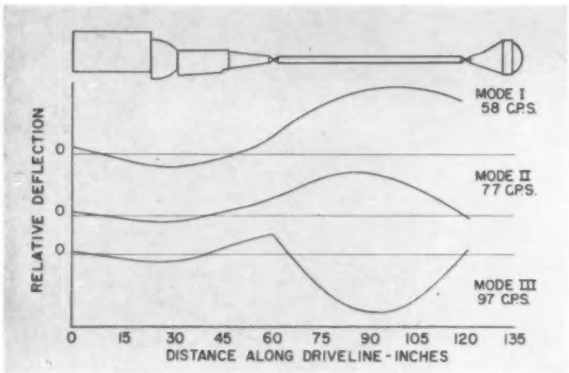


Fig. 3 — Vertical bending mode shapes.

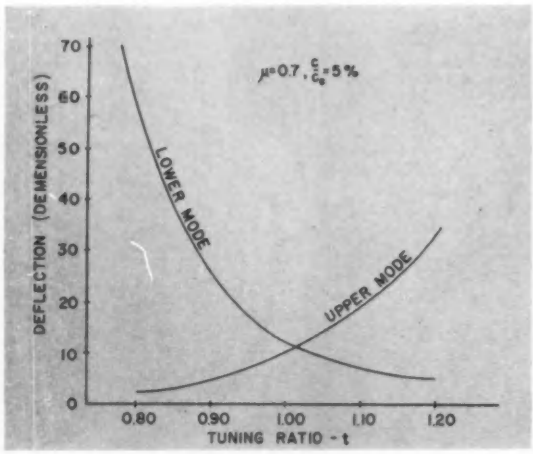


Fig. 4 — Relation of propshaft deflection to tuning ratio for damping 5% of critical.

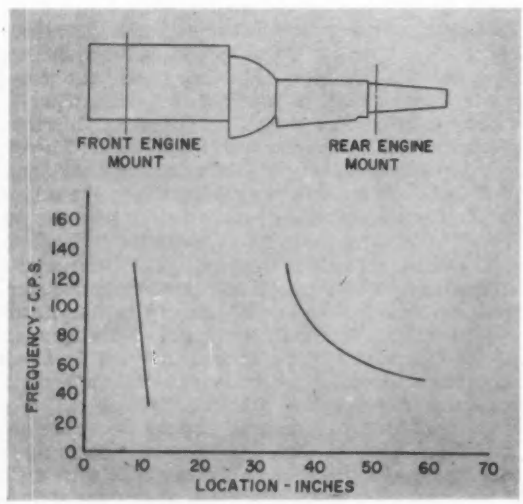


Fig. 5 — Vibration node location.

zero deflection and there would be one resonant frequency where the propshaft line crosses it.

Where the axle carrier is not rigid, there are provisions in the program for replacing the boundary constraint $y_n = 0$, with $V_n = ky_n$ where k is a tabular function of frequency which has been derived from experimental data and V is the shear force amplitude. This is shown in Fig 2.

In addition, it is possible to insert flexible mounts at any point in either member. This has application in such problems as that of center supported propshafts and has been used to confirm the unimportance of engine mounts to the critical speed problem.

Once the resonant frequencies have been determined, a second part of the computer program can be used to compute values of the forces and displacements for those frequencies at each of the increments. This permits us to draw mode shapes and to locate the points of high relative force and bending moment. Typical mode shapes are shown in Fig. 3.

The input is prepared almost entirely from detail drawings. As part of the preliminary chassis design procedure, driveline components are divided into increments, and masses and flexibilities are computed from measured areas and area moments of inertia. (The exception is the torque converter housing which is less a computation than an estimate based on measurement and experience.) The information is then entered into the computer in a form where the constants for each increment are on a separate input card. With this system, changes in length can be made by simply adding or removing cards and lineup of components is a matter of stacking appropriate decks of cards.

As it stands now, this program will give us only relative, not absolute, amplitudes. To take damping into account we develop the concept of tuning ratio as follows: the propshaft, being essentially a simple tube with no contained fluid or rubbing parts, contributes an insignificant part of the damping in the drivetrain. The major part is contributed by the engine and, to a lesser extent, the carrier. Considering only the prop and the powerplant, the problem is to gain some idea of how to make the damping that exists most contribute to the reduction of amplitudes at resonant frequency. It may be shown (Fig. 4) that there is a relationship between the ratio of the propshaft crossover frequency (the prop critical speed) to the powerplant resonant frequency and the amplitudes of the first and second resonances.

The output of the program may be varied to suit its purpose. In addition to locating the resonant modes (Fig. 2), mode shapes at the resonant frequencies may be plotted either in terms of deflection (Fig. 3) or equally well in terms of shear force or bending moment along the drivetrain. Fig. 5 is particularly useful in an understanding of noise phenomena. Since the noise due to second order vibrations is transmitted through the engine mounts, it will be proportional to the distance of the mount from the vibration node at the resonant frequency.

To order Paper No. 127C . . .
from which material for this article was drawn, see p. 6.

Are the compacts of the world in a HORSEPOWER RACE?

Based on paper by

John R. Bond

Publisher, Road & Track Magazine

A HORSEPOWER RACE seems to be on for the compacts — both domestic and foreign.

In fact one school of thought, primarily the sports car enthusiasts, believes that the smaller the car the more power it needs. There is much to be said for this:

- It furthers the compact's inherent traffic agility.
- Scalded-cat performance removes the last vestige of any onus that might be attached to driving a small car.
- A high-performance small car is much cheaper to operate than one with 300 bhp and 4000 lb.

At any rate, the current scramble for more power has started, whether we like it or not.

However, no other car from any country yet equals the 1 bhp/cu in. of the stock fuel-injection Mercedes-Benz 220-SE, or its torque rating of 1.135 lb-ft/cu in., either. Second in the power and torque department comes the Jaguar, with its dual overhead camshafts.

Table 1 lists some pertinent data for the standard engines on the six domestic cars and the four representative European ones.

How the hp is being pushed up

Currently, the Valiant's optional "Hyper-Pack" engine tops the field among the 6-cyl domestics, with 148 bhp — and simple proportion shows that nearly 195 bhp would be possible with the 225 cu in. version of their slant-6.

Corvair offers a package with an increase to 95 bhp, achieved primarily through a higher lift cam-

BOND'S ANALYSIS LEADS him to conclude:

"The current scramble for more power has started among the compact car makers . . . both in the United States and in Europe."

This article — the last in a series of three — details the data and trends through which Bond reached this conclusion.

The first two of this three-article series were:

IN the APRIL issue: "How Do the Compacts Compare?"

IN the MAY issue: "Suspension System Differences in the Compacts Are TREMENDOUS."

★

IN THIS article, as in the others of this series, Bond concentrates on the analysis of the six domestic compacts: Corvair, Falcon, Lark, Rambler A and B, and Valiant, and four typical foreign cars coming within the accepted definition of a compact (100-110-in. wheelbase). The foreign cars are: Jaguar 3.8, Fiat 2100, Mercedes 220, and Peugeot 403.

All these cars have 6-cyl engines, except the 4-cyl Peugeot. (In fact, no French manufacturer today builds a 6-cyl engine.)

Table 1–Data for Standard Engines

	No. of Cylinders	Valves	Type of Combustion Chamber	Bore, in.	Stroke, in.	Stroke / Bore	Displacement, cu in.	Bhp	Hp / Cu In.
Corvair	6	Pohv	W	3.38	2.60	0.771	139.6	80	0.573
Falcon	6	Pohv	W	3.50	2.50	0.715	144.3	90	0.623
Valiant	6	Pohv	W	3.40	3.12	0.920	170.2	101	0.594
Lark 6	6	Sv	L	3.00	4.00	1.33	169.6	90	0.530
Rambler A	6	Sv	L	3.12	4.25	1.36	195.6	90	0.460
Rambler B	6	Pohv	W	3.12	4.25	1.36	195.6	125	0.639
Peugeot	4	Pohv	H	3.15	2.87	0.911	89.5	66	0.738
Fiat 2100	6	Pohv	H	3.03	2.89	0.954	125.3	95	0.758
Jaguar 3.8	6	Dohc	H	3.42	4.17	1.22	230.6	220	0.955
Mercedes	6	Sohc	W	3.15	2.87	0.911	133.9	134	1.00

Are the compacts of the world in a HORSEPOWER RACE?

. . . continued

shaft and an enlarged exhaust system. Falcon's nominal 90 bhp can be boosted to 128 via three carburetors, a new camshaft, and other undisclosed modifications — all listed as factory options.

American Motors merely had to drop the overhead-valve version of their 195 cu in. engine into the American. This model — called the Rambler American Custom — gives them a boost from 90 to 125 bhp. A twin-throat carburetor version could be used — to give 138 bhp at 4500 rpm. The V-8 Rebel offers up to 215 bhp, officially, but American Motors also builds a V-8 with larger bore (327 cu in.), with up to 270 bhp at 4700 rpm.

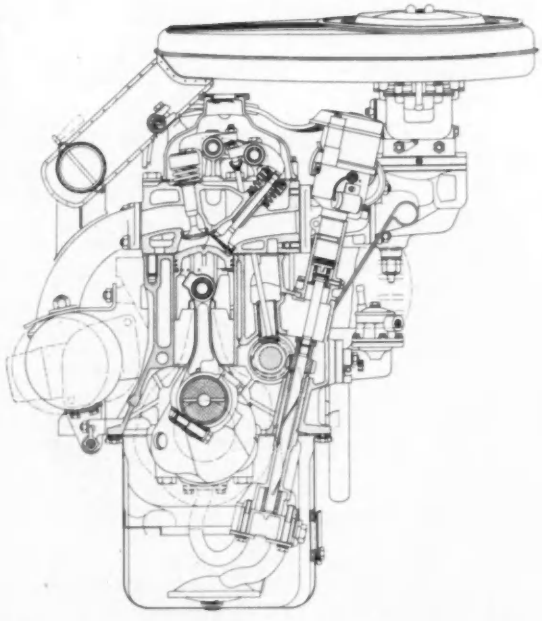


Fig. 1 — Fiat 6-cyl engine features unique inclined valve head with small quench area.

Lark has the 180-bhp V-8 engine available. Its longer stroke V-8 (with 289 cu in.) is being built for the Hawk with up to 225 bhp at 4500 rpm.

Jaguar's unique (for a production type) double overhead cam engine was designed shortly after the war. Its output has gone up steadily from 160 bhp in 1948 to over 265 bhp (at 5500 rpm) today. With years of racing experience behind them, Jaguar could easily offer the 3-carburetor version of this 230.6 cu in. engine. This combination in the current Jaguar 4-door sedan (having a very low coefficient of wind resistance) would undoubtedly be the fastest of the entire group.

Panhard's little aircooled twin is now available in Tigre form with horsepower increased from 42 to 50. Carlo Abarth offers kits for the Fiat that give a boost from 95 bhp to 125. Ford Consuls can be purchased in England with up to 80 bhp instead of 61. Humber recently enlarged its unit to produce 130 bhp. The Austin A-99 engine delivers 112 bhp, but the same basic unit is rated at 136 bhp in the Austin-Healey sports car.

Other engine characteristics

Engine location is unimportant, assuming that ride and handling are satisfactory to the general public. It is also assumed that the cab space can be utilized properly. For example, the extremely short centerline-of-front-wheels to centerline-of-brake-pedal dimension for the Corvair (17.5 in.) could be maintained with a front-mounted V-4 engine. This dimension is even shorter in the VW and Renault — at the expense of front-wheel house encroachment, which is so serious that only two people can be accommodated in the front.

At any rate, our 10 comparison cars have rather similar engines in major items, with the exception of the flat-6 Corvair and the 4-cyl Peugeot. The aircooling — or, more correctly, direct-cooling — of the Corvair engine offers many practical advantages for the consumer, particularly as to reliability and freedom from loss of fluid worries. Disadvantages appear to be, primarily, a slight but definitely higher

Torque, lb-ft	Lb-Ft / Cu In.	Compression Ratio	No. of Mains	Diameter of Mains, in.	Rod Length, in.	Rod Diameter, in.	$\frac{l^*}{r}$	
125	0.895	8.0	4	2.10	4.720	1.80	3.63	Corvair
138	0.956	8.7	4	2.25	4.855	2.12	3.88	Falcon
155	0.911	8.5	4	2.75	5.707	2.19	3.65	Valiant
145	0.855	8.3	4	3.06	6.375	1.81	3.19	Lark 6
150	0.767	8.0	4	2.48	6.625	2.095	3.12	Rambler A
180	0.920	8.7	4	2.48	6.625	2.095	3.12	Rambler B
85	0.950	7.5	3	1.97	5.197	1.77	3.62	Peugeot
106	0.845	8.8	4	2.48	5.216	2.09	3.61	Fiat 2100
240	1.04	8.0	7	2.75	7.750	2.19	3.71	Jaguar 3.8
152	1.13	8.7	4	2.36	5.315	2.13	3.70	Mercedes

* Length of connecting rod (center to center) divided by crank throw radius.

first cost and the power absorption of the cooling fan. Liquid-cooled engines have a fan too, but the power required to turn them at high speed is reduced by the propulsive effect of the air blast through the core. The aircooled engine's fan doesn't have this advantage and the further necessity of using a lower compression ratio indicates that we must accept a 5% (or more) drop in power for the same displacement.

Extra inches are cheap and this brings up a question: Why are the displacements selected for some of these new compacts so low? The answer isn't obvious to an outsider. It does seem odd . . . and somehow American Motors, with 195.6 cu in. of piston displacement, seems to be in an enviable position — although Valiant can easily slip in the 225 cu in. version of their slant-6 if the compact power race persists.

The Falcon goes extreme on stroke/bore ratio and is an extremely good design from the standpoint of cost of manufacture. The Valiant engine looks sturdy, if a little heavy — obviously designed for future use of aluminum in the block. The accessory arrangement saves one inch in overall engine length,

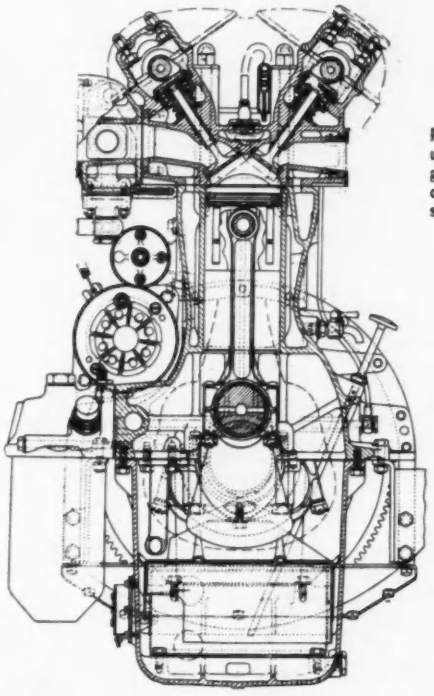


Fig. 2 — Jaguar 6-cyl engine has dual overhead camshafts.

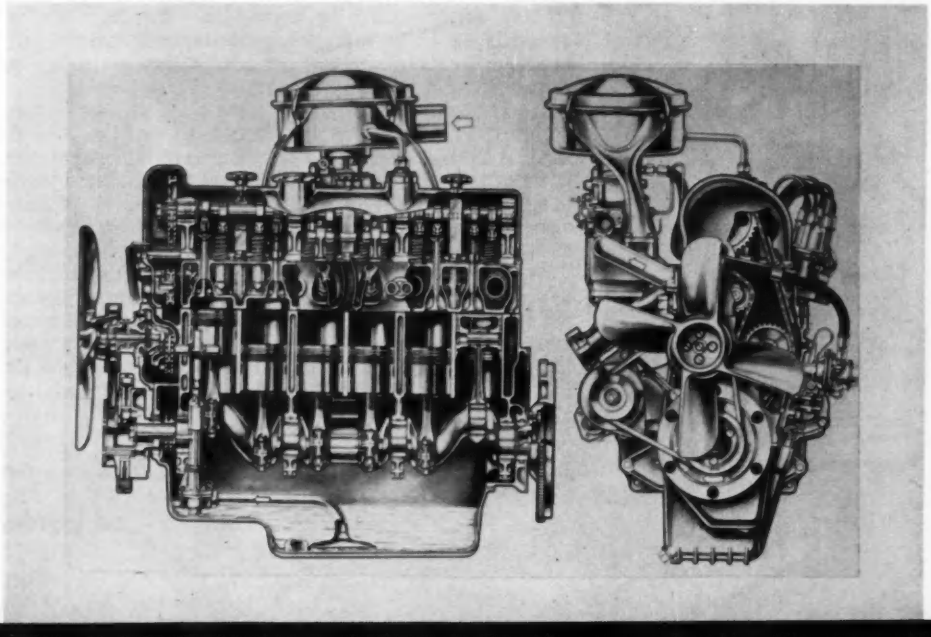


Fig. 3 — Mercedes 6-cyl engine has single, chain-driven overhead camshaft. It has been designed to run continuously at 6000 rpm.

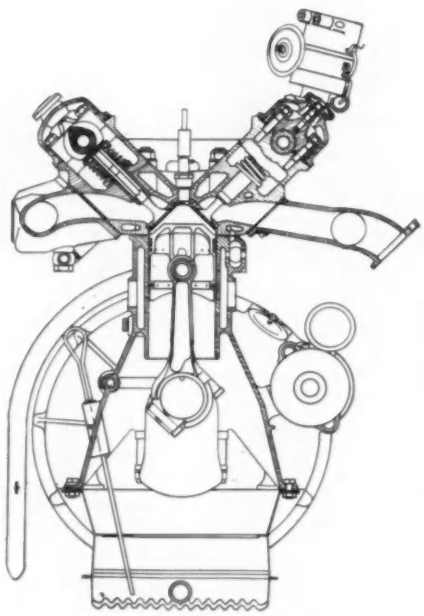


Fig. 4 — Alfa Romeo engine.

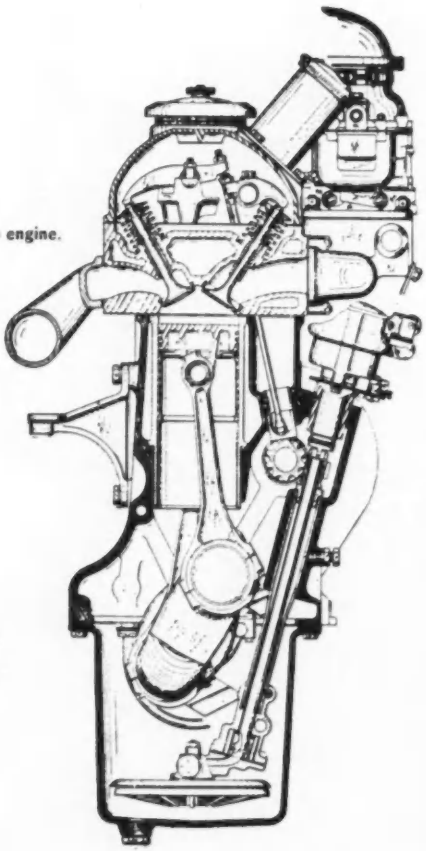


Fig. 5 — Citroen engine.

which fact, converted to bore size, indicates that it occupies no more space than a conventional 6 with cylinder diameters of 3.23 in.

The Studebaker 6 dates back to 1939, but main bearings are now no less than 3.06 in. in diameter, to achieve torsional rigidity. The price paid for this appears to be somewhat higher than normal friction: about 33 bhp at 4000 rpm with bare engine. The two Rambler powerplants are virtually identical except for valve location and, being large, they can operate at low revs/mile and give nearly as good tank mileage as smaller displacement engines in comparable chassis. Incidentally, these engines have extremely short connecting rods at only 1.56 times the stroke ($l/r = 3.12$). This appears to be the lowest ratio ever.

The four foreign examples chosen all differ materially from U. S. practice. Peugeot has used push-rod-actuated valves in H-type (hemispherical) combustion chambers for 15 years. The heads are cast aluminum and the included angle between valves is 48 deg. The cylinder block is cast iron with wet sleeves.

The new Fiat 6 (Fig. 1) features a unique inclined valve head with a small quench area. Though the combustion chamber appears to be hemispherical, the machining operations performed on it give it a more complex shape.

Despite rather long connecting rods and small crankpins on the Jaguar double overhead-cam engine (Fig. 2), it never seems to give trouble. Its size and weight (about 575 lb with aluminum head) put it at a disadvantage in a compact car. The latest bored-out version, known as the 3.8 sedan, has siamesed cylinders, as do several other compacts, including the Rambler, the Lark, and the Mercedes.

The Mercedes 6-cyl engine is surprisingly small — only 134 cu in. However, it has a single, chain-driven overhead camshaft and is said to be designed to run continuously at 6000 rpm (Fig. 3). Three versions of this unit are produced, of which the most powerful employs manifold injection by a Bosch intermittent-type pump.

It is rather interesting to note that European designers do not share our belief in future higher octane ratings. Of course, what are compact cars to us are large cars in Europe, but eight of the 19 imported cars listed in Table 1 (of Part I of this series, April issue p. 39) use hemispherical combustion chambers. These are the Alfa Romeo, Citroen, Fiat, Humber, Jaguar, Panhard, Peugeot, and Lancia (Figs. 4–7). In addition, the Rover uses an F-head, while all Mercedes models have single overhead camshafts except the 180-D — a push-rod-diesel. Thus, the majority of the European compacts do not favor the W or wedge chamber so universal in this country.

To order Paper No. 152B . . .
from which material for this article was drawn, see p. 6.

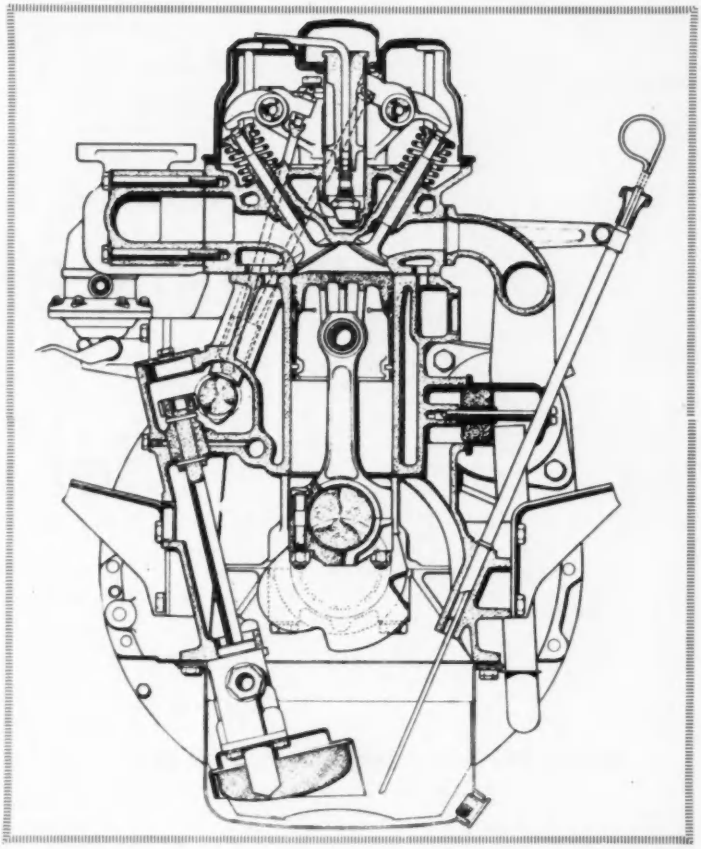


Fig. 6 — Humber engine.

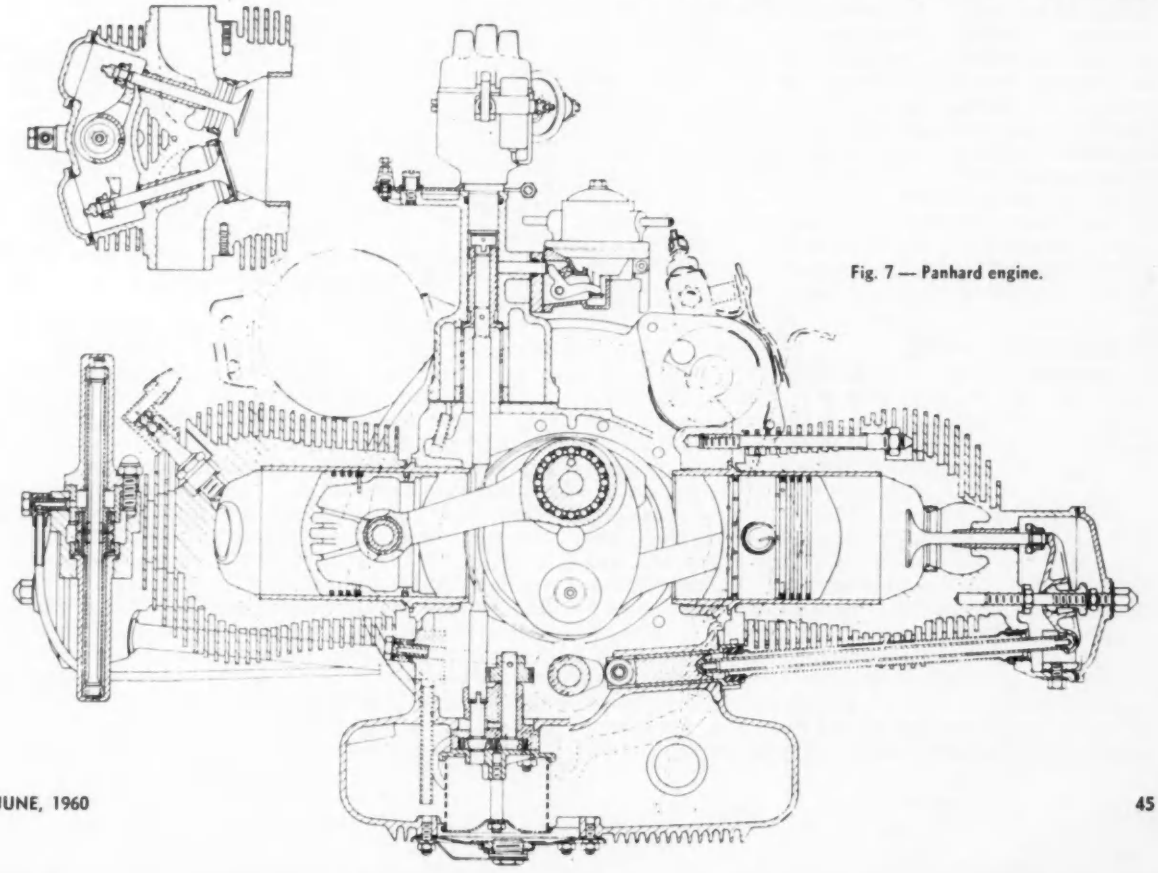


Fig. 7 — Panhard engine.

PEBBLE BED REACTOR

for nuclear space

Based on paper by

Myron M. Levoy and John J. Newgard

Reaction Motors Division, Thiokol Chemical Corp.

PEBBLE bed reactors are an interesting possibility for use in nuclear space vehicles during the next 10 years. Proposed Saturn boost vehicle payload capabilities are well-matched by the range of applicability of pebble bed reactors to space vehicles. The pebble bed reactor offers fuel element simplicity and versatility with respect to differential uranium loading. However, propellant pressure drops across the core are higher than for parallel plates or rods and structual supports are as difficult to construct. Nevertheless, the simpler elements with differential uranium loading radially and axially may affect an overall cost saving and might reduce reactor development time.

Reactor construction

A typical pebble bed reactor core is shown in Fig. 1. It can be compared with a typical parallel plate core, which is shown in Fig. 2. Both cores are surrounded by a beryllium oxide lateral reflector. In the case of the parallel plate core, the reflector might consist of blocks with coolant holes; in the pebble bed system, the reflector consists of BeO pellets. Reactor control is achieved in both systems via rotating elements in the reflector, containing boron for neutron capture. In the parallel plate system, the control elements are rotating protions of cylinders, which move in slots in the reflector; in the pebble bed case, the rotating elements are somewhat simpler BeO drums using borated stainless steel on a portion of the surface. (The use of cylindrical plates results in lower moment of inertia and faster response times.)

The parallel plate core permits (in the design of Fig. 2) the use of structural supports throughout the core with a distribution of the load. On the other hand, the pebble bed core utilizes a tungsten retention screen backed up by graphite support beams at the hot end of the core. The graphite beams, which may be reinforced with tungsten wire bundles, are 24–30 in. deep. The beams seat directly on the convergent nozzle wall. The wall consists of regeneratively cooled tubes brazed together and wire-wrapped on the outer surface of the nozzle, commonly called "spaghetti" construction. Some of the problems in this support approach include high weight of structures and thick regenerative tube walls, which would be required; the possibility of nozzle wall burnout from high wall temperatures near the beams; and the possibility that the core may displace downward if the convergent nozzle wall expands due to the core load or high temperatures.

An alternate support technique would transfer the core load up to the cold end of the reactor. The scheme, shown in Fig. 3, utilizes tungsten screens in the form of concentric baskets tied, via a breech connection, to the concentric graphite cylindrical partitions (which also serve to create separate flow passages). The load is taken through the graphite cylinders to the cold end, where the cylinders are attached to cylindrical metal hangers via segmented clamping rings. The hangers, in turn, are attached to extension rings integral with the pressure dome via clevis-type connections. In the case of the typical nuclear space vehicle, the load from internal drag is in the range of 1.2 million lb. A preliminary stress analysis indicates that the system of Fig. 3 is feasible for such a distributed load; the two inner graphite cylinders will be about 1.5 in. thick, the outer one about 1 in. thick.

In the scheme of Fig. 3, the reflector BeO pellets

looks OK

vehicles

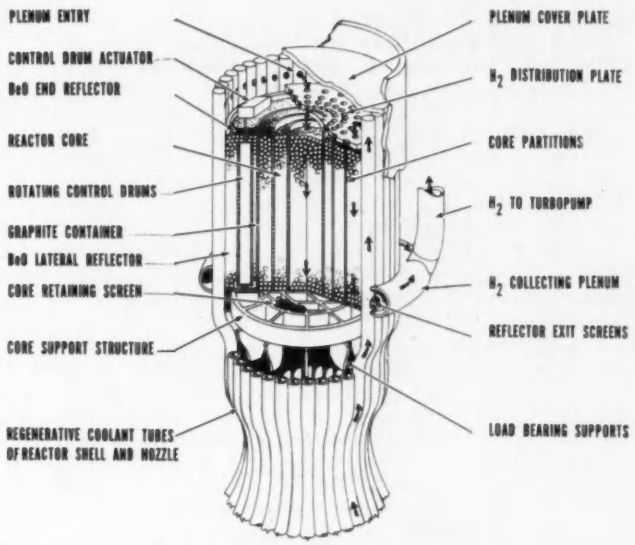


Fig. 1 — Typical pebble bed reactor for rockets.

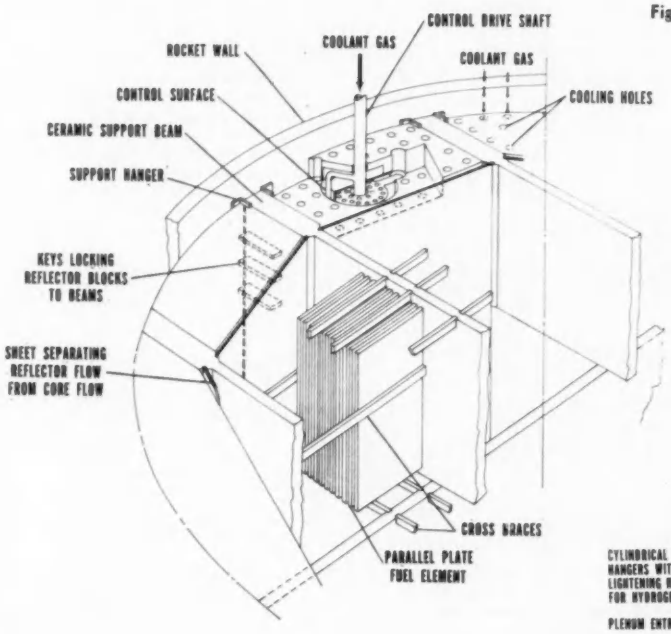


Fig. 2 — Typical rocket reactor core with flat plate fuel elements.

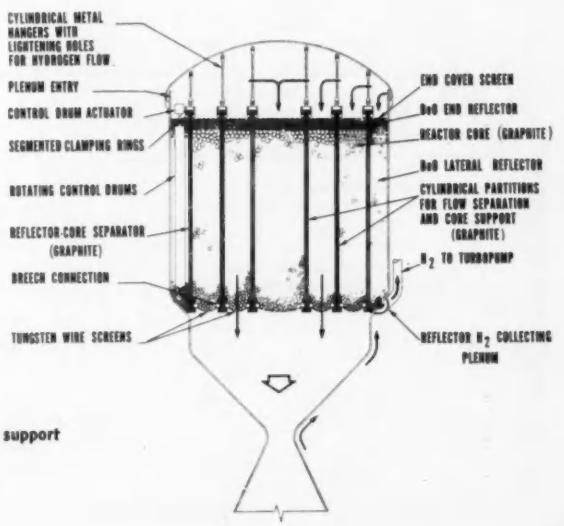


Fig. 3 — Pebble bed support scheme using wire screens.

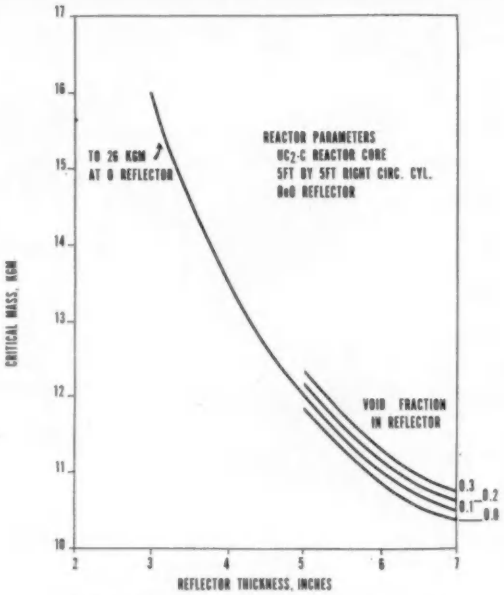


Fig. 4 — Critical mass of reactors for space vehicle propulsion.

nuclear space vehicles

. . . continued

are supported by the chamber wall. The hydrogen coolant in the reflector is separated from the core flow by the outer graphite cylinder. The gas leaves the reflector at 1500 F and is ducted to the turbopump for drive gas. Penetration through the chamber wall is effected by flattening or pinching some of the tubes in a uniform manner around the wall. A metal screen is used at each opening to

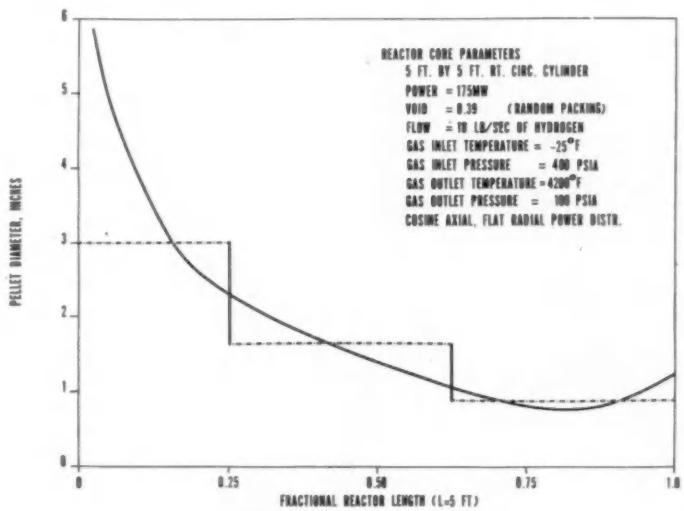

REACTOR CORE PARAMETERS
5 FT. BY 5 FT. RT. CIRC. CYLINDER
POWER = 175MW
VOID = 0.39 (RANDOM PACKING)
FLOW = 10 LB/SEC OF HYDROGEN
GAS INLET TEMPERATURE = -25°F
GAS INLET PRESSURE = 400 PSIA
GAS OUTLET TEMPERATURE = 4200°F
GAS OUTLET PRESSURE = 100 PSIA
COSINE AXIAL, FLAT RADIAL POWER DISTR.
PELLET DIAMETER, INCHES
FRACTIONAL REACTOR LENGTH (L=5 FT)

Fig. 5 — Pebble diameters in reactor for space vehicle propulsion.

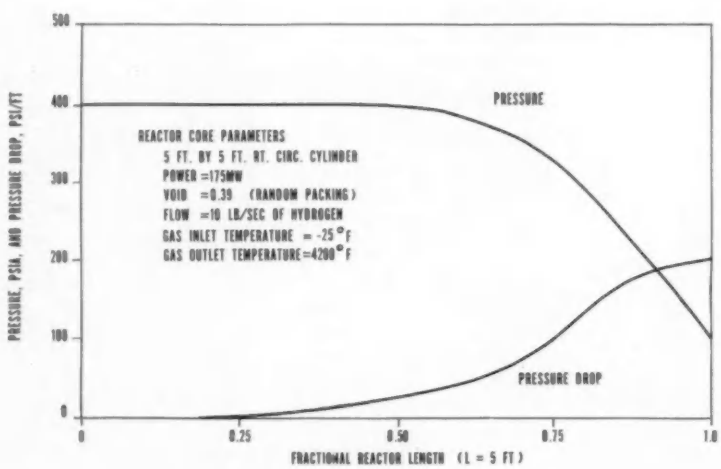

PRESSURE
REACTOR CORE PARAMETERS
5 FT. BY 5 FT. RT. CIRC. CYLINDER
POWER =175MW
VOID =0.39 (RANDOM PACKING)
FLOW =10 LB/SEC OF HYDROGEN
GAS INLET TEMPERATURE = -25°F
GAS OUTLET TEMPERATURE=4200°F
PRESSURE DROP
PRESSURE, PSIA, AND PRESSURE DROP, PSI/FT
FRACTIONAL REACTOR LENGTH (L = 5 FT)

Fig. 6 — Axial pressure profile in reactor for space vehicle propulsion.

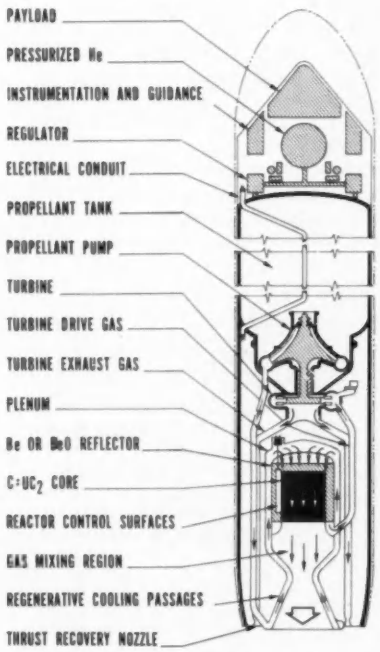
retain the pellets and a plenum is welded in place to collect the reflector flow.

Nuclear and flow considerations

The core has been compartmented for better flow distribution and a flatter gas temperature profile at the exit. The cylindrical graphite separators also serve as load-bearing members in the scheme of Fig. 3. Due to flux-buckling in a homogeneously fueled core, there is an increasing power density at the core center and, consequently, flow will tend to channel toward the outer periphery of the core. To prevent this, differential radial uranium loading would be required to flatten the power profile. (However, power flattening must not be achieved at the expense of the ability of the reflector drums to provide the reasonably large reactivity changes anticipated, which might average ½% in $\delta k/k$ per drum.) Also, flow in each compartment would be "orificed" by means of the end reflector, that is, the BeO sphere sizes would be appropriately varied in each compartment to permit greater flows through the high power regions.

The same technique would be used to reduce the flow through the lateral reflector to the required value (about 3.5% of the total flow.) In order to maintain a high ratio of solid to total volume in the reflector, mixed sphere sizes will be used such that 30% of the spheres will have sphere diameters one-fifth that of the remaining 70%. In this way, by properly choosing the diameter of the spheres (while maintaining the 1/5 ratio), the flow rate through the reflector may be fixed at the design value.

Fig. 4 shows the variation of critical mass of the reactor with reflector thickness and reflector void fraction for a 5×5-ft. right cylindrical core of uranium loaded graphite pellets and 40% void fraction in the core. In order to minimize engine weight, it is desirable to have as thin a reflector as possible (compatible with a low uranium inventory), as shown in Fig. 4, and a controllable reactor, that is, one with a reasonably large average neutron lifetime. In prior work with flat plate element cores and solid BeO reflectors with cooling holes, it was found that a 6-in. reflector with 10% void provided a satisfactory design. Such low voids are virtually impossible with pellet beds that may be reasonably fabricated, since the filling of voids with smaller pellets results in new voids requiring still smaller pellets, ad infinitum. Therefore, the dual pellet size with 1/5 diameter ratio previously mentioned was used. The resulting 30% void may be compensated by an increase in critical mass of 0.3 kg. The cost of this additional U^{235} would be relatively negligible, while the savings in



Schematic diagram of nuclear rocket.

A SCHEMATIC DIAGRAM OF A NUCLEAR ROCKET using a bleed cycle (reflector coolant hydrogen used to drive the turbopump) is shown at left.

The flow of hydrogen propellant may be followed from the pump through the regenerative cooling passages of the nozzle and reactor chamber; through the end reflector and the reactor core; and out the nozzle.

The small percentage of total flow (~3%) that cools the reflector and drives the pump may be used for thrust vector control or thrust recovery.

This system is the one considered here.

nuclear space vehicles

. . . continued

reflector fabrication and structures cost are believed to be considerable.

From Fig. 4 it can be seen that, alternately, compensation can be achieved by increasing the reflector thickness to 6.6 in. In this case, however, the cost of boosting the increased weight (450 lb) into a 300 nautical mile orbit would be on the order of $250,000.

The effect of using cores with higher void fractions, as previously discussed, is to lower propellant pressure drop and so permit higher flow rates or lower inlet pressures. However, the critical mass of such a core will increase considerably and the reactor will be less thermal. For example, in the present case of a 5×5-ft right cylindrical reactor with a void fraction of 0.39, the critical mass is 11.4 kg (Fig. 4). For the same reactor with pellets in a cubic array, the critical mass will be about 16.1 kg. The cost of the additional U^{235} is offset by the reduced cost of launching the lighter reactor; in fact, a net savings of about $500,000 is possible. However, the reactor control may be more difficult in the faster reactor, and reliability poorer. Also, the cost of fabrication of the cubic array in a cylindrical core will be higher than for random packing.

In order to attain a relatively low pressure drop of propellant through the reactor core by maximizing pellet diameter, the pellet diameters must be varied in the axial direction, as indicated in Fig. 5, resulting in the axial pressure profile of Fig. 6. These curves refer to a 33,500-lb gross weight vehicle with a 10 lb per sec flow rate, but similar results are obtained for cores with higher flow rates. In actual practice, the pellet diameters might be stepped in three or more groups, as indicated in Fig. 5. In fact, a smaller pellet diameter may be necessary in the first group at the cold end of the reactor to reduce the pellet-diameter-to-effective-bed-diameter ratio and hence prevent excessive wall channeling and large average void fractions due to gaps along the walls.

To fix pellet diameter at the largest permissible value at any point in the core, both temperature and thermal stress limits must be observed. The thermal stress was held to 70% of the reported tensile strengths and maximum pellet center temperature was limited to 4500 F. The resulting maximum and average pellet temperatures are shown in Fig. 7. From this, it may be seen that the thermal stress limit (at the sphere surface) was controlling for the first half of the reactor length, while the temperature limit controlled for the remainder. This pattern of temperature-stress limitations appears to hold for all reactors considered, including the plate cores for high flow boost vehicles; however, the point where maximum temperature starts controlling sifts somewhat for different cases.

To order Paper No. 165B . . .
from which material for this article was drawn, see p. 6.

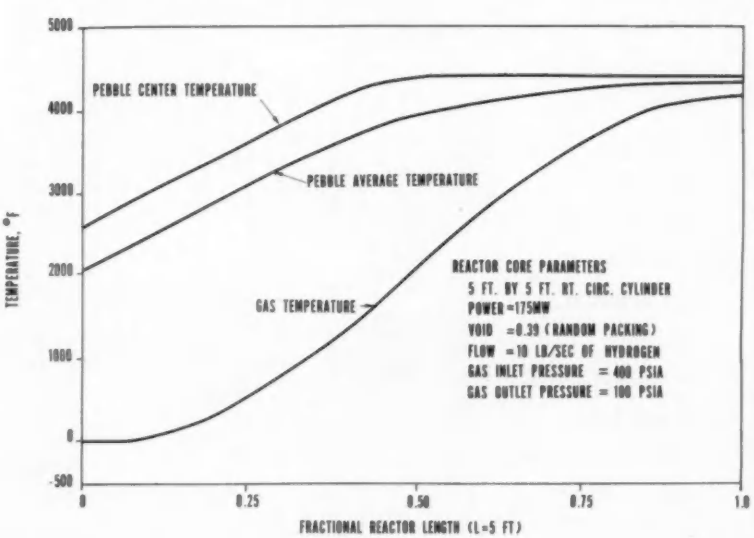


Fig. 7 — Axial temperature profile in reactor for space vehicle propulsion.

Analytical Methods Bringing BREAK-THROUGHS in MATERIALS HANDLING

Based on secretary's report by
Edward J. Hayes
Thompson Ramo Wooldridge, Inc.

MATERIALS HANDLING begins with the vendors plant and ends with the delivery of a product to its user . . . and modern analytical techniques are helping to get optimum results along many steps of the way.

The modern techniques — most of which are based on "probability" procedures of some kind — are spreading steadily but slowly. They are an expense to use. Consequently, producers can properly install them only after careful study of applicability to individual situations.

Different techniques, of course, are found to fit different conditions . . . of quantity requirement, available equipment, and existing manufacturing facilities. Work Sampling, the Queueing or waiting-in-Line Theory, and the Monte Carlo method are good examples of the variety of techniques now available.

Work Sampling, for example, is likely to be used for making decisions as to acceptance or rejection of a product already past a given control point . . . or a product coming from a process over which statistical control has not been exercised. In this method, decisions are reached by comparison of the measurable characteristics of the product with previously-determined standards.

The Queueing Theory, also called the "waiting-in-line" theory, was first applied to working out the requirements of new telephone switchboards. Now it is being applied to any operation where units arrive at an irregular rate at some point, from which they are passed on to some other point at a different rate. Aircraft arrivals at a busy airport and automobile traffic in general are two good examples of current application. (Central problem of the queueing theory is to calculate the relationship between the mean length of the waiting line and the degree of randomness of arrival and disposal. . . . The calculations are not too difficult, if both arrivals and servicing take place in a purely random manner.)

The Monte Carlo Method is a technique whereby data are generated by use of some random number generator . . . a pack of cards, dice, perhaps a roulette wheel.

The data of interest (such as number of rejects in a given batch) are plotted or tabulated as a cumulative probability distribution function. Then, each random number or series of numbers which is "generated" is used as a decimal value of the cumulative probability. The number in the data-of-interest corresponding to this cumulative probability value in the chart or table is then obtained.

Recently a number of companies have adopted specialized procedures to improve processes in the area between the end of the vendor's line and the beginning of the buyer's manufacturing line. In this much neglected area, these producers are achieving substantial cost savings. The savings involve improvements in packaging, loading, transporting, and unloading.

Typical of innovations which are bringing about improvements in these areas is Western Electric's combining of a closed TV circuit with public address systems to control incoming truck shipments.

Incoming highway truck traffic at WE's Hawthorne Works is heavy and continuous. Each incoming load is routed to a specific truck dock — of which there are 17 — by a control room presided over by a single operator. He scans the incoming truck over a closed-circuit TV setup and talks with the truck drivers through a public address system. He finds out what each is carrying and directs them to the proper docks, or to a weighing scale. Thus, each truck goes directly to the "right" dock and is quickly unloaded by specially-designed fork trucks.

Kinetic packaging is another process by which materials handling between vendor and user is being improved. Named by General Motors' Ralph O'Reilly, Jr., kinetic packaging is based on the idea that a package — besides just protecting goods —

should be a dispenser . . . a magazine which feeds the parts into automatic assembly machines.

The kinetic packaging principle was borrowed from such things as the .50-caliber machine gun cartridge belt, which not only got the cartridges into the gun (the package), but also positioned and dispensed them in the automatic machine for which they were intended.

General Motors uses this principle in the case of bearings, which are received in long, thin, cardboard packages. The packages are inserted vertically into the bearing assembly machines . . . and the bearing, already positioned by the package, feeds out by gravity. The long, thin packages are shipped to GM in large unit loads.

Subsidiary benefits great

While admittedly high in actual cost, use of modern analytcal techniques has brought important subsidiary benefits to most manufacturers who have installed them. One successful producer, for example, testified recently that:

"The supplementary benefits are tremendous. Usually, the great advances achieved result from the activity involved in setting up the system.

"Most of these systems can't be used unless new disciplines are set up throughout the handling operation. The disciplines required, in other words, automatically bring into being a better solution to the overall problem. . . . The extra benefits often are analogous to those gained by installing an IBM system — where the number of clerks eliminated is not nearly as important as the improvements in the general procedures necessary to make use of the IBM system possible."

The real problem, according to another experienced producer, is not the cost of using the modern analytical techniques themselves, but the finding of equipment which will satisfactorily do the job the way the analysis dictates.

Studies, for example, told one manufacturer that he needed a much simpler routing of his job shop work to varying stations. He didn't find it easy to arrange.

Another producer, faced with a somewhat similar problem, standardized his boxes and containers, and programmed a Barret Cravens tractor to follow a scheduled route and make programmed stops. Having checked costs carefully, he found it would be cheaper to keep a man on the job than to put in automatic equipment.

In justifying capital expenditures in this materials handling field, one producer starts with the concept that one man at $5000 per year equals 5% of a $100,000 investment . . . and he finds that often he doesn't need to make installations which, at first, seemed necessary, because 90% of his savings were already achieved from improvements resulting from the act of setting up the necessary systems for the new installations.

There are many criteria by which a materials handling operation may be judged as good, bad, or indifferent. One easy-to-apply criteria is this: The existence of inventory in the aisles is an indication of poor handling.

To Order SP-330 . . .
from which material for this article was drawn, see p. 6.

LIGHT GAS "New"

Based on paper by **John M. Stevenson**
Lycoming Division, AVCO Corp.

WITH SMALL, lightweight, 1000-hp-and-up gas turbines now available, a new generation of highly mobile, off-the-highway vehicles may be born. Such vehicles, extending the present range of mobile vehicles to larger capacities, could exploit the light weight and small size of these turbines to the limit. In such vehicles, these "first-generation" gas turbines would not compete directly with the diesel . . . any more than the gasoline engine was a straight alternative to the horse. (If a particular one of these extended-range vehicles happened to need the characteristics of both a turbine and a diesel, at different times, a case might be made for an installation using one of each.)

Assuming that this "new" off-highway vehicle was designed to use a gas turbine to begin with, the main problems would revolve around the engine and transmission characteristics required.

Engine characteristics

A power range of 1000 hp or more can be assumed because it is about in this range that the gas turbine starts to become really interesting as a mobile powerplant. In this range, for an equivalent degree of conservatism in design, the gas turbine's weight will run to only 1/20th of that of a diesel . . . if we consider a specific weight of more than 1 lb/hp unnecessarily solid.

This "first-generation" 1000-hp turbine is likely to weigh 1000 lb, occupy 15 cu ft of space and cost $40,000. (In smaller sizes the gas turbine would probably not be selected. The less power a vehicle design requires of a gas turbine, the more difficult it is to design the turbine. That is why the gas turbine probably has its most immediate possibilities for application in large off-highway equipment.)

When the "second-generation" of small, lightweight gas turbines comes along in quantity production three to five years hence, price levels only half as high as now can be expected.

The turbine power rating for this possible new generation of large, off-highway vehicles had best be quoted at the maximum power required for a hot day at altitude . . . say for 100 F at 5000 ft altitude. Then the design should automatically limit the engine so that it never delivers more than this.

Abridgment of an
SAE Central Illinois Section Paper

TURBINES May Power Off-Highway Vehicles

This procedure recognizes that the turbine produces 50% more power on a zero day than on a 100 F day in summer . . . and that its power falls off with altitude, due to the reduced air density. (At 10,000 ft, less than 70% of sea-level power is produced.) So, this "flat-rating" of the engine eliminates the need for carrying a lot of extra weight in wheels, transmissions, fuel systems and auxiliary drives to take the maximum power available to suit the coldest day imaginable at sea level. ("Flat-rated" engines are in wide use on aircraft and insure the equipment always gets all the power it can use, but no more.)

Power loss caused by soot deposits on the compressor blades can be restored by throwing a few handfuls of ground walnut shells (or other soft particles) into the engine while it is running. The blades are cleaned off immediately. (Steam-cleaning is not usually successful.)

Particles of dust in the air, smaller than 100 microns, have no apparent effect on the gas turbine engine . . . but sand (over 100 microns) erodes the blades and reduces efficiency. When working with earthmoving equipment, substantial filters would be used on the air intake.

This 1000-hp engine weighing somewhere between 500 and 1000 lb can be switched about without much handling. Idle vehicles need not tie up valuable engines . . . and turbines with overhaul periods as low as 1000 hr may turn out to be entirely economical.

Transmissions

Building the transmission to go with the gas turbine on these large off-highway vehicles may turn out to be much more difficult than fitting the gas turbine engine itself to the requirements.

To begin with, a 1000-hp gas turbine turns at 30,000 rpm or thereabouts — which must be geared down to less than 100 rpm at the wheels of a big vehicle. Second, in a simple single-shaft turbine engine, the output torque falls off as speed is reduced, even more rapidly than in a piston engine.

Thus, a mechanical transmission would use a primary reduction gear with a ratio of 15 to 20/1; a 10 or 12-speed shift gearbox, and possibly a hydraulic torque converter as well. Even with planetary drives on the wheels to give a low-torque differential, the weight of the system would amount to 15 or 20 times that of the turbine engine alone.

By using a somewhat more costly 2-shaft turbine, with a free-wheel acting as a high-speed torque converter, the starting torque can be improved considerably. Although it is still not sufficient to eliminate a gearshift, the job is easier.

To be really attractive, the transmission must be comparable in weight and compactness to the turbine engine. Mechanical variable-ratio gears have been built in the 100-hp range . . . and studies have been made of their possible use.

As things stand today, it appears that electrical drive, with separate dc motors on each wheel, is the most practical for large off-highway equipment.

Brakes

Large quantities of air at from 50 to 120 psi are available with the gas turbine installation to operate brakes . . . without having to install a separate engine-driven compressor. If electrical transmission is used, the wheel motors probably would be driven as generators. The energy can then be dissipated either through resistance coils, or by driving the engine.

The compression of a 1000-hp gas turbine engine absorbs up to 2000 hp itself. So, if the fuel supply is turned off, there is plenty of engine braking available . . . and the heat generated goes straight up the exhaust.

Accessories

Accessory power for hoists, winches, drill, etc. can be drawn in the usual way from an engine-driven hydraulic pump — or with an electric motor. Also, the gas turbine makes available large quantities of hpt exhaust gas at 800 to 1000 F which can be used for melting sticky or frozen earth if need be.

Noise problem small

Excess noise is not likely to be a problem with gas turbines installed in large off-highway equipment. Most objectionable noise from gas turbines comes from the exhaust . . . and gas turbines used for driving machinery would have much smaller and quieter exhausts than those used for jet propulsion of aircraft. (A 1000-hp shaft gas turbine uses only 5% as much air as an airline jet . . . and ejects it at only 300 fps as compared with up to 2000 fps for the jet.)

To order Paper No. S239 . . .
from which material for this paper was drawn, see p. 6.

Ceramics help solve

▶Bodies and coatings made are successfully

Based on paper by

William T. Monagle

Thiokol Chemical Corp.

FINDING SUITABLE MATERIALS for rocket engines has been a major problem over the years. This article covers some of the many ways in which ceramic bodies and coatings have been used in the solution of rocket problems.

An example of the application of ceramic bodies to the solution of a typical liquid propellant rocket engine problem is the work done by Reaction Motors on an engine system to operate at 50,000 lb thrust for 25 sec as a booster unit for a ground-to-air missile system. This unit was operated on red fuming nitric acid and anhydrous ammonia. Since low cost, simplicity of operation, and conservation of critical materials were main objectives, it was decided to use a pressure system with an uncooled thrust chamber (Fig. 1). This unit used such alloys as 4130 and 17–22A(s) as jacket materials and various ceramic bodies and backing cements as lining materials.

As a preliminary to building the full-scale engines, a series of small-scale engines were fabricated and fired as a screening procedure for nozzle and lining materials. These tests were made under the following operating conditions:

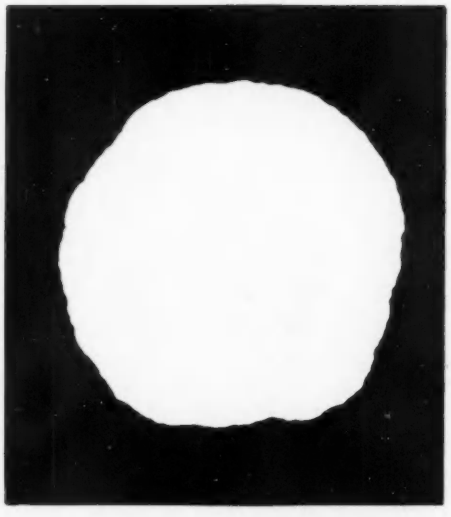
Thrust: 575 lb
Chamber pressure: 450 psi
Oxidizer/Fuel ratio: 2.05
Specific impulse: 210 sec

Most of the values given are average because of variations caused by tank pressure fluctuations, nozzle erosion, and similar factors affecting performance.

Figs. 2–12 show the most interesting nozzles upon completion of testing with shadowgraphs showing the extent of the damage done to the nozzles.

As a result of these tests, a study of liner costs,

Fig. 2 — Nozzle material: TAM Zirconia; total time: 17 sec; area change: 58.2%. Comment: Nozzle appears to have been severely damaged as a result of thermal shock. Only a semblance of the original configuration remains, although no cracking or damage of the backing material occurred.



rocket problems

from ceramics

replacing other materials.

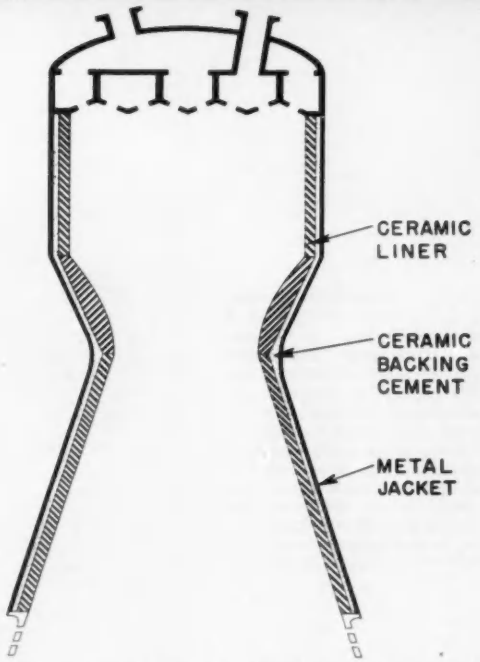


Fig. 1 — Uncooled thrust chamber with ceramic liner and backing cement.

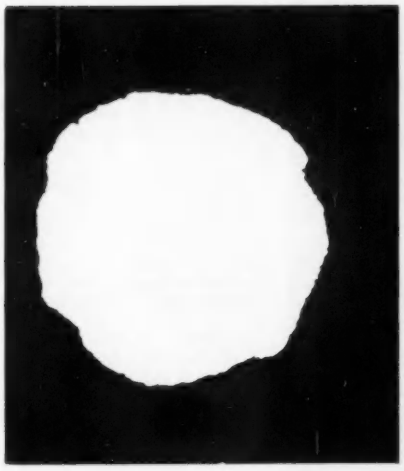
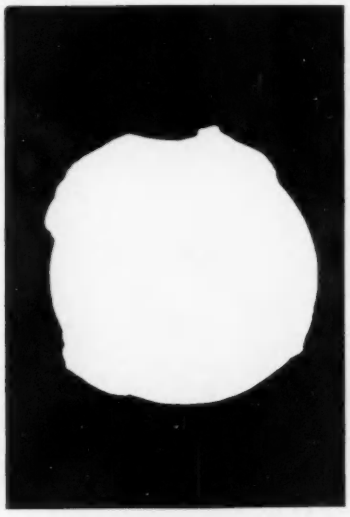


Fig. 3 — Nozzle material: Speer Grade 3383 Electrode Graphite; total time: 21 sec; area change: 71.8%. Comment: This material is of no use whatever in this unit, since complete erosion of the throat area occurred.

Fig. 4 — Nozzle material: Molybdenum Disilicide coating on Graphite; total time: 22 sec; area change: 7.16%. Comment: Nozzle erosion occurred in several areas where the coating cracked and allowed the exhaust gases to contact the Graphite substratum.



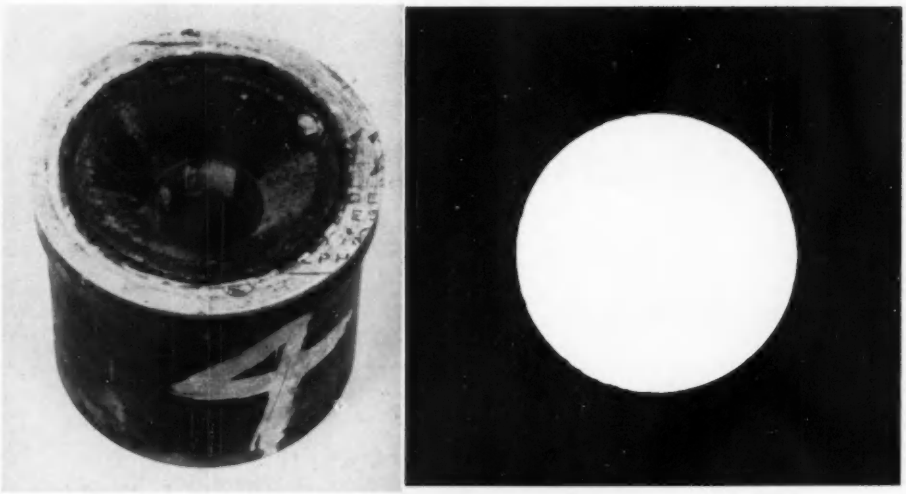


Fig. 5 — Nozzle material: Boralite (Zirconium Boride) insert in Graphite; total time: 23 sec; area change: 0.45%. Comment: Failure of this unit was due primarily to erosion of the convergent graphite cone and to a radial crack through this section to the case. The insert shows no sign of erosion but, a hairline circumferential crack exists at the midpoint. This crack, however, is not so severe as to have prevented continued operation.

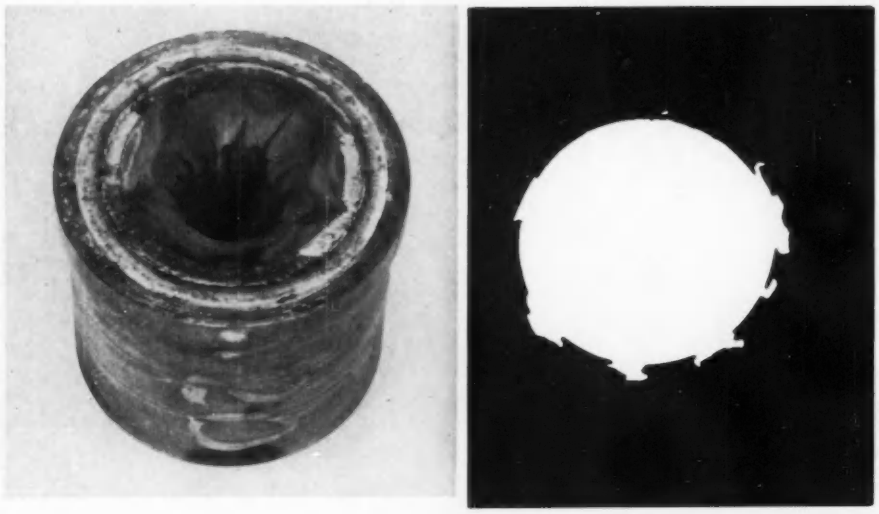


Fig. 6 — Nozzle material: Silicon Carbide coating on Graphite; total time: 25 sec; area change: 4.08%. Comment: The entire throat area exhibits signs of severe erosion, but in a pattern indicating that the coating first failed in a series of radial cracks. Two radial cracks caused a complete split of the nozzle itself, but did not result in destruction of the backing material.

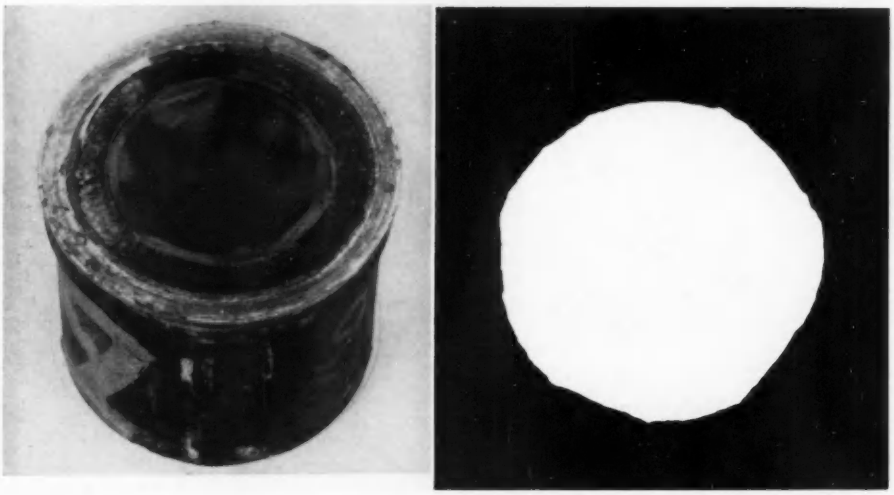
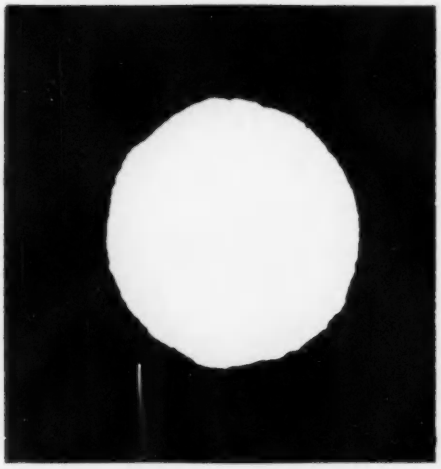


Fig. 7 — Nozzle material: National Crucible 830; total time: 24 sec; area change: 2.36%. Comment: Erosion of this unit was very even, but slightly more pronounced along the injector streak locations. Body appears sound. In fact, the edge of the converging cone, which had projected approximately ⅛ in. into the chamber section, remained sharp.

Fig. 8 — Nozzle material: National Crucible 830; total time: 66 sec; area change: 13.58%. Comment: Erosion along the ox streaks is pronounced, and marked roughening of the convergent and throat sections has occurred. The edge of the convergent section is almost completely destroyed and it appears that the bond has been affected in the convergent section.

Fig. 9 — Nozzle material: Slip Cast Niafrax; total time: 17 sec; area change: 8.70%. Comment: The general nozzle appearance is very good, some erosion occurring at the throat — particularly along the injector streaks. Erosion appears to have occurred primarily in the destruction of the fine grain surface layer to expose the larger particles in the core.



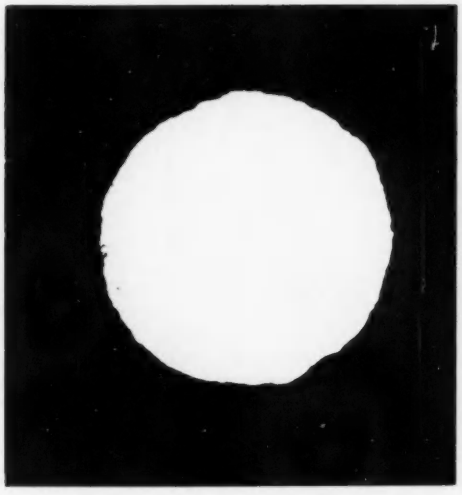


Fig. 10 — Nozzle material: Niafrax A; total time: 116 sec; area change: 15%. Comment: This nozzle was run five times with run durations ranging from 17–25 sec. The nozzle was still in good condition at the end of 73 sec. Cracks extending through the wall to the backing cement occurred at the end of 95 sec and erosion in an uneven pattern had developed by the end of the last run.

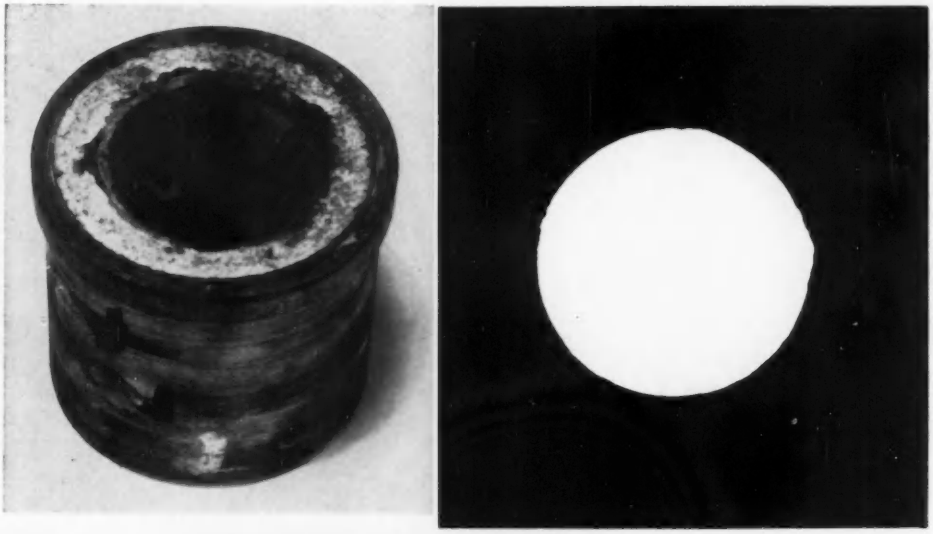


Fig. 11 — Nozzle material: Crystolon-N; total time: 88 sec; area change: 0%. Comment: This unit, although much smaller in throat diameter than the others used, is perhaps the best appearing of all those tested. The backing cement apparently has a fairly high degree of refractoriness but did fail along the convergent edge and was replaced with Alfrax in that area. Marked streaking of the unit is present, and, the only erosion, which actually amounts to no more than a roughening of the surface, is present in those areas. A single radial crack (actually no more than a hairline) extends from the convergent edge to the throat entrance. The unit probably would continue to withstand repeated operation.

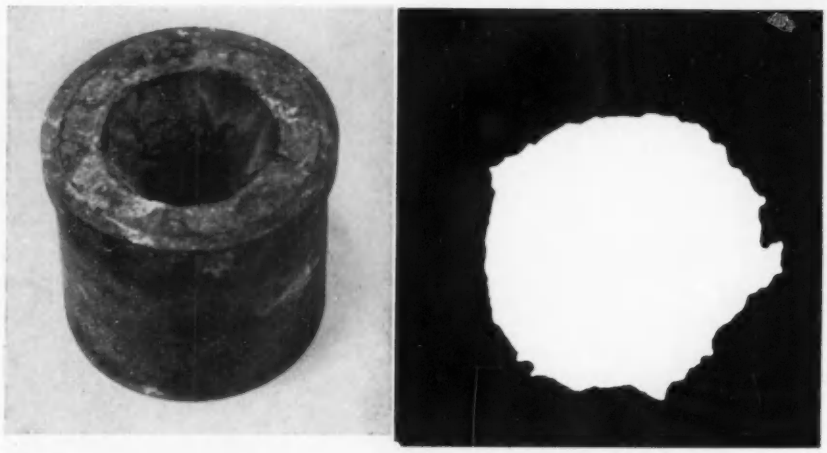


Fig. 12 — Nozzle material: Alfred A-410; total time: 6 sec; area change: 29.5%. Comment: Complete destruction of the material appears to have occurred as a result of pieces pulling loose because of the high gas velocity. One radial crack extended to the wall and resulted in a burnout approximately ¼ in. in diameter.

availability, and weight, it was decided to concentrate on Niafrax A and Crystolon N bodies, both of which are silicon nitride bonded silicon carbides, as nozzle materials and upon Grade 3383 Electrode Graphite as the combustion chamber and exit cone liner material.

Since the test results with National Crucible 830, a carbon-bonded silicon carbide, had proven so promising, it was decided to investigate the possibility of obtaining full-scale pieces for all three liner sections in this material.

One of the problems to be overcome in a unit of this type is the bonding and supporting of the ceramic bodies in the metal jacket. In this case, a mixture of gypsum cement and flake graphite provided an adequate solution. The assembly procedure used with this chamber is shown in Figs. 13–22.

A silica bonded zirconia cement in combination with interlocking liner pieces proved suitable for preventing gas leakage at the liner joints.

Close control of the factors affecting the strength of the backing cement is extremely important to insure the reproducibility of performance of this type of chamber. Among the more important variables requiring control are the age of the cement, slaking and mixing times, the amount of water used in the mixture, and the process used in curing the material.

Extensive testing during which a series of more than 200 runs were made over an extended period, under a wide variety of operating conditions, proved the adequacy of this design and of the graphites Crystolon N and Niafrax A originally selected for the job.

Our work in attempting to incorporate full-scale pieces of National Crucible 830 proved unsuccessful, however, when spalling and cracking of the test shapes shown in Fig. 23 occurred in every case.

It is felt that the difference noted in the small-scale and full-scale tests resulted from differences in the fabricating procedures used in the different size samples.

The press used for forming the small specimens proved to be of insufficient capacity to achieve the

Fig. 13 — Fixture for thrust chamber assembly.

Fig. 14 — Nozzle extension mounted on fixture.

Fig. 15 — Exit cone liner in place.

Fig. 16 — Positioning of thrust chamber jacket.

Fig. 17 — Applying cement on throatpiece.

Fig. 18 — Applying cement on thrust chamber liner.

Fig. 19 — Clamping chamber liners in position.

Fig. 20 — Marmon joint — nozzle extension to jacket.

Fig. 21 — Pouring ceramic liner backing.

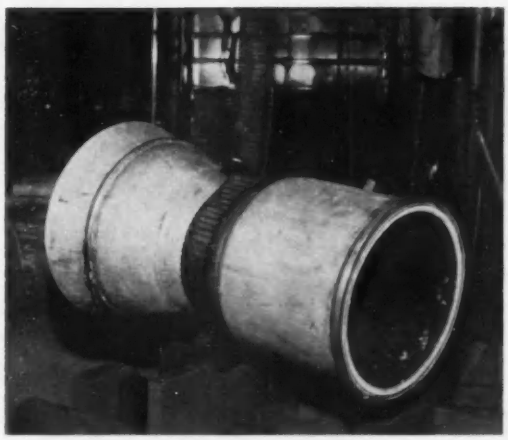


Fig. 22 — Completed thrust chamber.

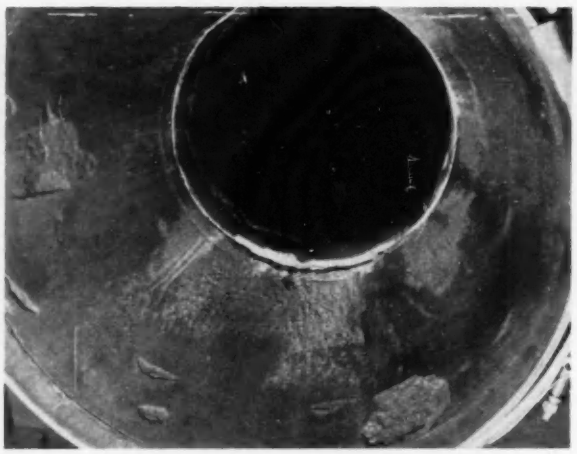


Fig. 23 — Full-scale tests of National Crucible 830 were unsuccessful. Spalling and cracking of the test shapes occurred in every case.

small nozzle density on the large pieces and a spinning-type pressing technique used for crucibles produced the laminations which apparently caused spalling.

Guardian engines

Another type of pressure-fed liquid-propellant engine on which Reaction Motors recently completed development is the packaged liquid powerplant used in the Guardian engines developed for the Sparrow III (Fig. 24), and for the Bullpup (Fig. 25).

These units incorporate the various advantages of the solid propellant motor, that is, ease of handling and storage, instantaneous readiness for use with the higher performance, improved temperature stability, as well as the advantages of the liquid propellant engine.

The sectional view of the Bullpup (Fig. 26) shows the construction of these units.

The unit consists of a pair of propellant tanks surrounding a chamber containing the pressurizing medium (in these units a solid propellant grain) and a second chamber in which the combustion occurs. A coating of Rokide Z forms an insulating layer on the cooled aluminum combusion chamber wall and on the copper nozzle and exit cone.

Performance tests on these units have been successfully completed and production contracts for both engines have been awarded to Reaction Motors. The Rokide coating has proved reliable and the coating process has proved amenable to operation by manufacturing personnel without extensive training.

The use of the Rokide process, despite the disadvantages of high rod material cost and a lower application rate than the powder-type flame spray processes, is based upon test results indicating a high degree of reliability and superior adherence and erosion resistance to the powder-type coatings.

In a production operation, it is possible to pur-

Fig. 24 — Packaged liquid powerplant used in Guardian engine developed for the Sparrow III.

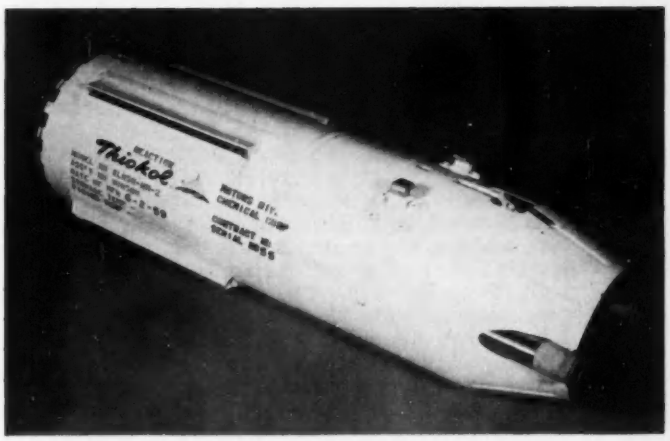


Fig. 25 — Packaged liquid powerplant used in Guardian engine developed for the Bullpup.

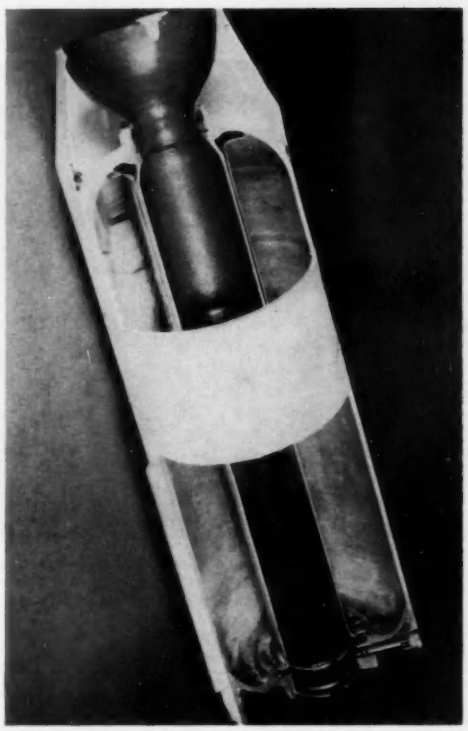


Fig. 26 — Sectional view of the Bullpup showing unit's construction.

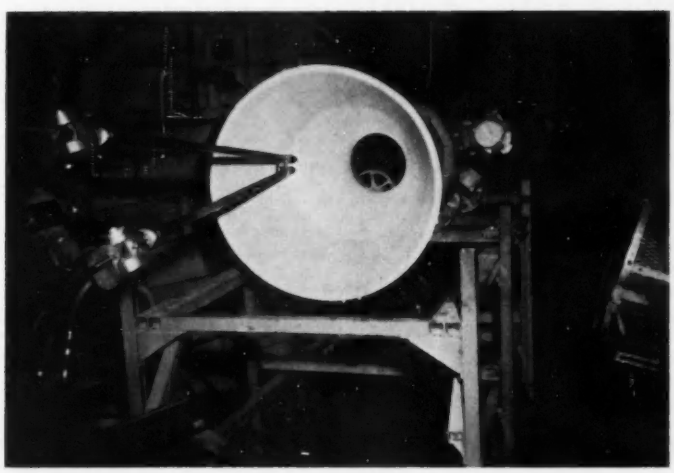


Fig. 27 — Procedure used to coat regeneratively cooled thrust chamber developed for the X-15.

Ceramics help solve rocket problems

. . . continued

chase larger quantities of rods with resultant reduction in unit cost.

The lower rate of application is more difficult to overcome. For applications where the most obvious solution — use more guns — is impossible because of the size or shape of the unit being coated, the recent development of improved flame spray guns and of large diameter rods (3/16 and ¼ in.) should prove to be a reasonable answer. Since the large diameter rods are easier to produce, the per pound cost of the coating material in these sizes is much less than that of the ⅛ in. rods originally employed.

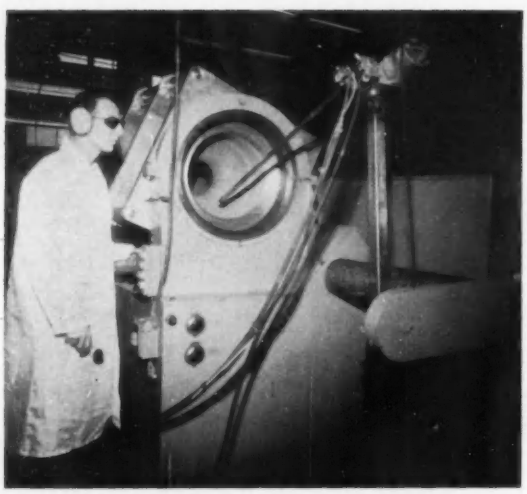


Fig. 28 — New semi-automatic coating machine is capable of applying a uniform coating at a closely controlled spray angle in a reproducible manner. The unit is set up for metallizing.

The use of the large diameter rods thus becomes a method of increasing application rate and of reducing material cost.

In addition to the Guardian engines, Reaction Motors is also using the Rokide Z coating on the regeneratively cooled thrust chamber developed for the X-15. The system is a turbo rocket type, with firing times ranging up to 5 min and cyclic operation (repeated stops and starts an absolute necessity).

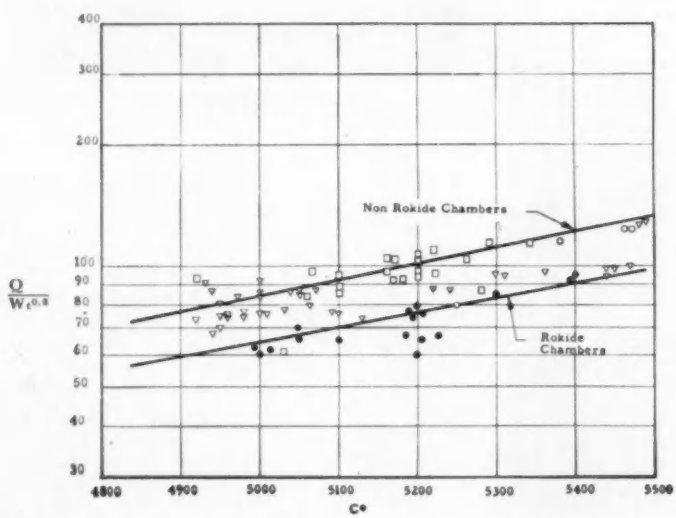
Fig. 27 shows the procedure used in coating this type of chamber. Control difficulties with this coating technique led to the design of the semi-automatic coating machine shown in Fig. 28. The unit is set up here for the metallizing operation. This machine is capable of applying a uniform coating at a closely controlled spray angle in an extremely reproducible manner.

A question sometimes raised on the use of these insulating coatings is "What do we really gain?" Fig. 29 answers this question. Here, the heat input to the coolant $Q/W^{0.8}$ has been plotted against C^* for test results obtained with both coated and uncoated thrust chambers used in conjunction with various injector configurations. Note that a decrease of approximately 20% has been effected in the heat input to the coolant in the coated thrust chambers.

The applications of ceramic bodies and coatings reviewed in this article are but a few of the many where ceramic materials have proven their worth in rocket engine applications.

In addition to the present areas of application, a large number of new areas and new materials remain to be explored. There is little in the way of precedent to guide the designer and very little information available in the literature that can be related to the operating conditions to which the materials will be subjected in such applications. The success of many of our future rocket developments, however, depends upon the successful accomplishment of these materials exporations.

To order Paper No. 168B . . .
from which material for this article was drawn, see p. 6.



$Q = W_{NH_3} \times C_{P_{NH_3}} \times T_{Coolant\ Jacket} = BTU/sec.$

$W_T = W_{NH_3} + W_{LOX} = lb/sec\ Total\ Propellant$

$Q/W_t^{0.8} = \frac{BTU/Sec.}{(lb/sec)^{0.8}}$

$C^* = \frac{P_c A_t g}{W_t}$

Where P_c = Pressure of combustion on rocket chamber, psia

A_t = Throat area of rocket chamber, in^2

g = Acceleration of gravity, ft/sec^2

W_t = Weight flow of propellants, lb/sec

Fig. 29 — A decrease of approximately 20% has been effected in the heat input to the coolant by coating the thrust chamber.

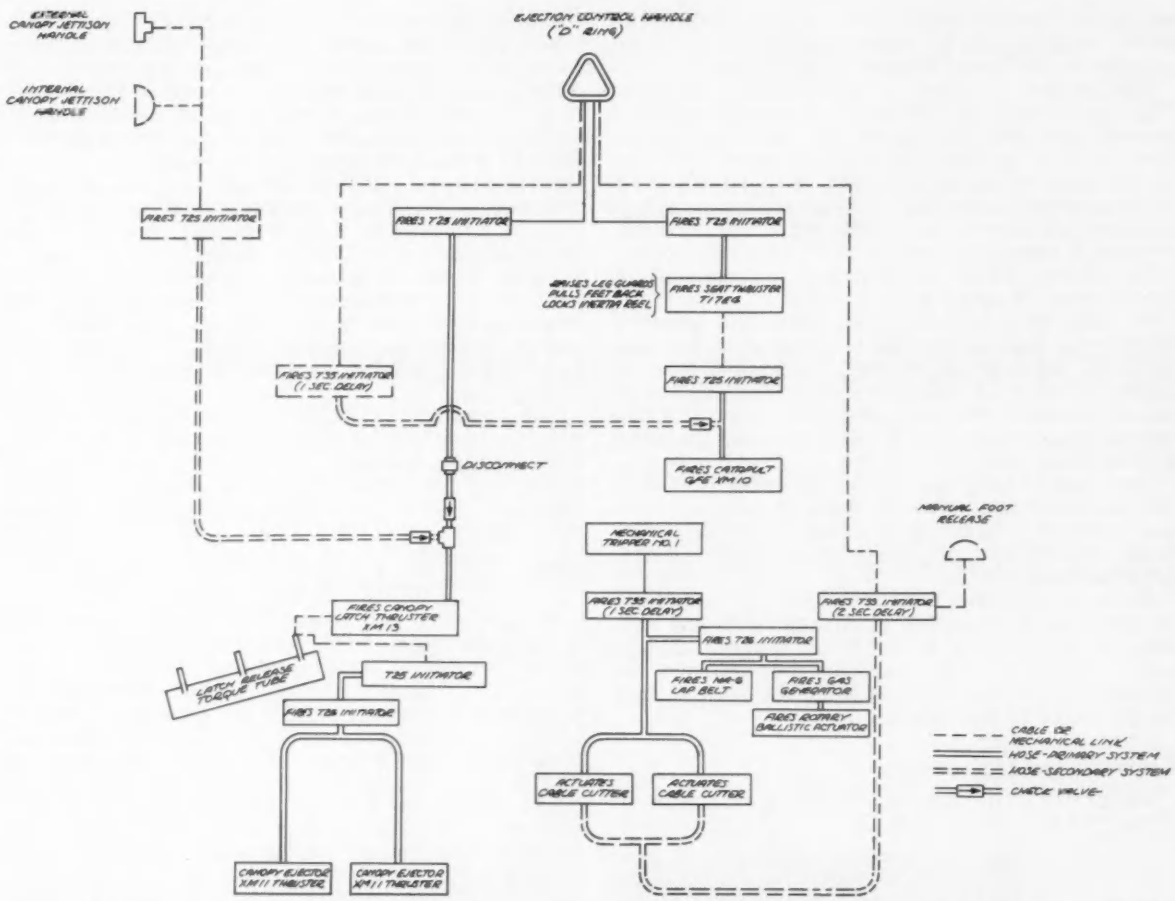


Fig. 1 — This upward seat escape system is used on the F-104. Aerial escape success rate has been raised to near 90% from the low of about 65% in 1945.

Readying crew stations for near-space aircraft

▶ Human engineering aims to integrate man, not to accommodate him, in the man-machine relationship.

Based on paper by

Major John A. MacDonald

Special Projects Branch, Aircraft Laboratory
Wright Air Development Division, Wright-Patterson AFB

CHANGES, advancements, and refinements to aircraft/spacecraft crew stations will come from a more intimate knowledge of the human being's abilities. In the man-machine relationship, man is the constant and the machine will be designed to complement and integrate him rather than accommodate him as we now do. We've just begun to engineer for this human being.

Human engineers of the Special Projects Branch have been able to lift the aerial escape success rate from a low of about 65% in 1945 to just under 90% this year. With this there has been a healthy increase in the success rate of subsequent survival attributable to constant improvement in personnel

equipment and survival training. The increased interest in flying the hot ones and the reduction in number of Air Force widows is gratifying.

The modern escape system is highly complex. Fig. 1 shows what it takes to operate the complete upward seat system in the F-104. All these thrusters, initiators, boosters, delayers, actuators, and catapults must work without fail to their designed force in proper timed sequence, under all operational temperature and field conditions. Our greatest problem is to assure crews that it will work successfully but only when set in motion early enough to complete its designed cycle.

We now have automatic lap belts and shoulder harnesses. Sensing devices cause them to position the body so that maximum accelerations can be absorbed correctly. Crew members now may work in unrestrained comfort and still have the full safety of restraining equipment available instantly and automatically.

Our sealant progress has made great strides in the last few years with the help of new polymers and silicones. However, radiation, algae, and very high temperatures are going to be tough barriers to break through.

We have glass and plastics in which we have faith for our near-space vehicles. Attachments and sealing will be our work area for the future. Optical and electronic equipment may soon replace the windshield. When this happens, the cockpit may be any place in the airplane.

Crew station area design

Refinements in the crew station area will be great, but we foresee virtually no basic changes in this area for the B-70 and Dyna Soar aircraft.

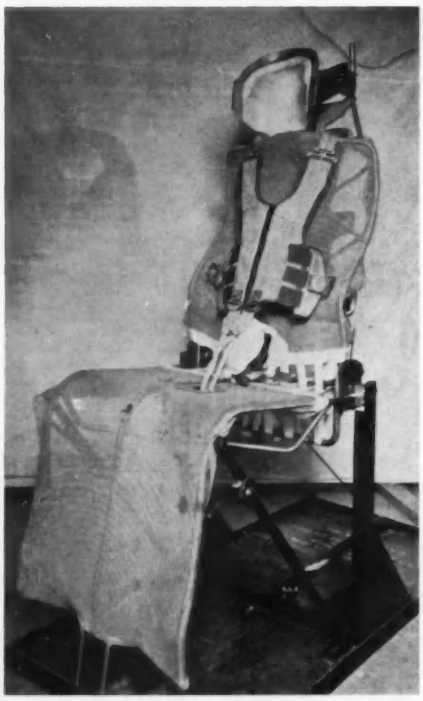


Fig. 2 — In this experimental, light-weight, net and tube crew seat, a trained rider can withstand 17g and do useful work for as long as 30 sec.

The design of most of the crew station components will closely follow today's configuration because the operator's experiences require this similarity. Vehicles will be controlled by hand motions rather than by brain wave impulse or eyelid flutter. Control motions will continue to be oriented to the vehicle motions whenever possible to maintain normal human reaction to motion.

Costs also militate against radical change. It is to the advantage of the Air Force to have as many common items as possible in weapon systems so that costs to the taxpayers are cut and the number of world-wide stock bins is reduced. Common fasteners for the Thor and Atlas, for instance, would be a big help. This is the old problem of Macy's telling Gimbel's.

Ten years from now the pilot will still sit in his machine and look at instruments; the cockpit will still resemble a cockpit. The pilot's sitting attitude may change in relation to the direction of motion, and there may be fewer gages to monitor to obtain more information.

Major advance in crew seats

By starting from scratch rather than adapting our design for a crew member seat, we have reduced the normal weight for seats by 90%, at the same time increasing the *g* load tolerance for the occupant by several hundred per cent. For example, a normal pilot starts having vision problems at about four times gravity. A pilot wearing a *g* suit and in good physical condition can withstand eight times gravity for several seconds before blackout. However, sitting in our new net and tube seat, just about anyone can ride in shirt-sleeve comfort at 12 times gravity and a trained rider can withstand 17*g* and turn out useful work for as long as a 30 sec or more. This experimental light-weight crew seat is shown in Fig. 2.

A by product of the design was a crash load absorption feature. A drop tower test made with an instrumented dummy in the seat showed that at 90*g* the attenuation of the net resulted in a 35*g* load on the dummy, which is well within human tolerance levels.

Strangely enough, the back angle and contour account for this enlargement of the human tolerance envelope. The new envelope allows booster engine design of twice the thrust and half the time and weight for certain types of proposed flights. A very thin wall, high-strength steel tube with tough synthetic fiber net account for the light weight high strength, high load dampening, and comfort in this seat.

At the present we are still stuck with sticks and wheels for controls, probably because Wilbur and Orville used them. However, we've been experimenting with an integrated seat-control idea in which the normal flying control motions would be made with the arm rests of the seat. Several mock-ups have been built, and one configuration has been flight-tested with some success. Some day it may make a big change in the cockpit. "Look Ma! No Wheel!"

To Order Paper No. 173B . . .
from which material for this article was drawn, see p. 6.

Statistical design techniques simplify

Multivariable Investigations

. . . reduce work needed to

- select area of interest in a complex study.
- explore it intensively.

Based on paper by

W. J. Youden

National Bureau of Standards

STATISTICAL DESIGN TECHNIQUES which have been developed in the last 15 years can greatly simplify multivariable investigations. These techniques can be used for complex studies where the experimenter is concerned with:

- Selecting for study a few important variables from a considerable number.
- Ascertaining the quantitative effects of variables already selected.

Screening the variables

Important variables are usually screened from a lengthy list by trying each variable at two or perhaps three levels. This task would be formidable if all possible combinations of these variables and their levels were investigated. Fortunately, there is no need to use more than a small fraction of these numerous possible combinations.

Fractional factorials — The problem is to select efficient subsets from the total array of possible experiments. In the technique using fractional factorials, the subsets are carefully selected in order to maintain a systematic coverage of the experimental region.

The general principle employed can be visualized by studying Fig. 1. The cube shows the eight possible combinations of three variables — A, B, and C — each at two levels. One corner of the cube is at the origin of three axes assigned to the three variables. . . . This origin corresponds to a selected initial level for each of the three factors. Point *a* corresponds to a change in variable A from the initial level to level *a*, the other two variables remaining at their initial levels. Similar statements hold for points *b* and *c*. Point *ab* corresponds to changes for variables A and B from their initial levels to the levels to the levels *a* and *b*, variable C remaining at its original setting. There are corresponding points marked *ac* and *bc*. Finally there is a point *abc* representing an

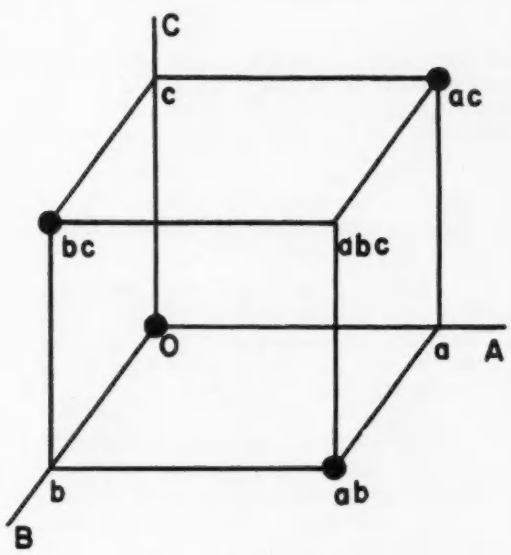


Fig. 1 — Eight corners of cube represent the eight combinations of three factors, each at two levels.

Table 1 — Classification of data in 4 groups to determine whether effect of variable in question depends on setting of another variable. Table is for a one-fourth subset of eight variables each at two levels.

Level for Variable B	Level for variable A	
	Initial	Alternative
Initial	Average of 16 results	Average of 16 results
Alternative	Average of 16 results	Average of 16 results

Table 2 — Weighing designs — schedule for eight experiments with seven variables at two levels.

	Experiment number							
Variable	1	2	3	4	5	6	7	8
A	0	0	0	0	1	1	1	1
B	0	0	1	1	0	0	1	1
C	0	1	0	1	0	1	0	1
D	0	0	1	1	1	1	0	0
E	0	1	0	1	1	0	1	0
F	0	1	1	0	0	1	1	0
G	0	1	1	0	1	0	0	1

experiment in which all three variables have been changed together.

If four experimental runs are made under the conditions specified by points *o*, *ab*, *ac*, and *bc* (indicated by heavy dots) the experimental space is covered in a uniform manner but at a lower density than would be achieved if all eight combinations were tried. If there are a sufficient number of variables, the subset may be ¼, ⅛, 1/16, or even smaller fraction, of the total number available.

Advantages of the fractional factorial are sensitivity for the detection of the effects of a variable, and ease in examination of the data. For all two-level programs, the subsets are of such a nature that half of the results are obtained with the variable at the alternative level. Thus the whole body of data may be divided into two equal parts and the average found for each part. Comparison of the two averages shows whether a change in the variable produces an effect on the average. The phrase "on the average" in this setting means over a considerable variety of combinations of the other factors. There will be a considerable number of results back of each average which greatly reduces the effect of random errors in the results.

These averages leave something to be desired because there are certain situations which are sensitive to changes in a particular variable and other situations where a change in this variable is of no consequence. If the subset isn't too small a fraction of the whole number of possible experiments, and is properly chosen, it can be determined if the effect of the variable in question does depend on the settings for other variables.

To do this, the data are divided into four groups with equal numbers of measurements in each group. If two variables — say A and B — are selected, the measurements are divided into the following groups: (1) all results where both A and B are at the initial level, (2) A is at the initial level and B at its alternative level, (3) B is at its initial level and A at its alternative level, and (4) both A and B are at their alternative levels.

Table I shows this classification of data. The averages for the four groups make it possible to compare the effect of variable A when variable B is at its initial level, with the effect of variable A when B is at its alternative level. A one-fourth subset of eight variables permits the construction of 28 such tables. These are all the possible pairings that can be formed among eight variables so that the influence of any one variable on any other variable may be determined. Clearly if the effect of a variable is independent of the level of another variable (or variables), this will greatly simplify subsequent work.

The experimenter, in some cases, may be fairly certain that some variables do act independently of other variables. In that case there is an advantage in giving up the opportunity to prepare the four groups for selected pairs of variables. The advantage comes in the opportunity to use a smaller subset. In selecting the subset the goal is to preserve the comparisons of interest and sacrifice those deemed unimportant or negligible.

The number of experiments can be cut down by changing the level of just one factor at a time. Suppose that a first run is made with every variable at some initial setting. Eight further runs may be made changing each variable in turn to an alternative level leaving the other variables set at their initial values. With this approach, the detection of an effect must be made on two single runs and the advantage of using averages is lost. Furthermore, the effect of the variable may depend on the choice of the initial set of conditions. The opportunity to detect interdependence of factors is also lost.

Weighing Designs — If the ability to detect interdependence of factors is going to be sacrificed, the technique of weighing designs is superior to changing one variable at a time.

Consider seven factors A through G and denote

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His previous experience includes 20 years as chemist and statistician at the Boyce Thompson Institute for Plant Research, and acting as an operations analyst with the Air Force.

the initial levels by 0 and the alternative levels by 1. Table 2 shows a schedule for eight experiments. The first experiment calls for all variables to be set at their initial levels. In each succeeding experiment, four of the variables are set at their alternative levels.

This method of assigning levels for the eight experiments introduces a desirable symmetry into the program. Each variable has been set at the initial level four times and at the alternative level four times. The four experiments at the initial level of any one variable include two runs at the initial level and two runs at the alternative level for each of the other six variables. . . . The same relationship holds for the four runs at the alternative level of that variable. Therefore changes in the other six variables are neatly balanced off against each other.

Consequently the two levels for any variable may be examined by comparing the average of four runs made at the initial level with the average of four runs made at the alternative level. This reduces the experimental error to one-half that applicable to comparisons between single results. The effect of changing a variable is also obtained over a broader range of conditions than the single point that is selected when one variable is changed at a time.

Intensive exploration of selected area

Once the important variables have been identified, a more intensive study may be undertaken to ascertain the conditions under which — for example — maximum horsepower will be obtained, or minimum consumption of fuel per mile achieved.

Factorial program may be too rigid — With the smaller number of variables, a complete factorial program would seem to make it possible to draw families of curves that would display all relationships involved. But there can be difficulties when the individual curves are not only displaced vertically on the graph paper, but are shifted laterally as well. Then a choice of levels suitable for defining the uppermost curve may miss the interesting parts of lower curves . . . the factorial experiment may be over-rigid.

Response surface designs — The observed responses of the system under investigation may be considered to be some unknown function of the variables. Suppose that the investigation has been narrowed down so that the interest lies in a fairly precise evaluation of the efforts of a few variables over a rather limited range of values. The observed response can be visualized as a surface which may, over not too large a region, be approximated by an empirical function of the variables under investigation. The function

$$R = b_0 + b_1x_1 + b_2x_2 + \ldots + b_{11}x_1^2 + b_{22}x_2^2 + \ldots + b_{12}x_1x_2 + \ldots$$

may serve as a suitable approximation, just as linear or quadratic interpolation is often used over short ranges of complex functions.

Evaluation of the coefficients in this equation requires some runs at predetermined levels of the variables. Schemes for selecting convenient combinations of levels of experimental variables have been evolved.

To Order Paper No. 116A . . .
from which material for this article was drawn, see p. 6.

B-58 Reliability

THE B-58 RELIABILITY PROGRAM has been comprehensively revealed by Convair and two subcontractors (Sperry and Emerson Electric) in SAE publication SP-183.

Although originally scheduled as a single presentation (Paper No. 157A) at the SAE National Aeronautic Meeting, the information expanded into a seven-part story of the overall reliability program Convair undertook under the weapons system concept.

The contents of the publication are:

Part I — General Organization, Approach, and Overall Features

Dr. N. H. Simpson, manager of reliability, Convair-Fort Worth, Fort Worth, Tex.

Part II — Mathematical Reliability Model

R. E. Brady, R. D. Chase and B. M. Wall, Engineering Systems Reliability Group, Convair-Fort Worth, Fort Worth, Tex.

Part III — Failure Reporting System

J. L. Coburn, reliability projects administrator, Convair-Fort Worth, Fort Worth, Tex

Part IV — Prime Contractor's Implementation Action with Subcontractors

J. L. Coburn, reliability projects administrator, Convair-Fort Worth, Fort Worth, Tex.

Part V — Sperry's Reliability Program for the B-58 Bombing-Navigation System

W. J. Huber, assistant director, Reliability and Quality Control, and E. Klosko, S. A. Rosenthal, W. J. Tompson, Reliability Engineering, Sperry Gyroscope Co., Great Neck, N. Y.

Part VI — Emerson MD-7 Fire Control System Reliability Program

Gene Barnard, chief, Reliability and Components Division, Emerson Electric Mfg. Co., St. Louis, Mo.

Part VII — Utilization of Data

N. H. Simpson, manager of reliability, Convair-Fort Worth, Fort Worth, Tex.

Axle and transmission requirements

Based on paper by

R. K. Nelson and L. J. Valentine

Eaton Mfg. Co.

THERE are marked differences in the lubrication requirements of a motor truck transmission and rear axle. Before a single lubricant can be developed which meets the requirements of both components, the differences in requirements must be investigated in respect to:

- Load carrying.
- Operating temperatures.
- Rolling and sliding velocities.
- Lubricant properties.

Load-carrying requirements

The transmission and rear axle must be able to absorb the engine torque and horsepower. Moreover, the lubricant must have its load-carrying characteristic aligned directly to the torque and horsepower requirements in order to insure proper lubrication of both transmission and rear axle parts under all conditions. Transmission and rear axle performances differ upon change in torque and horsepower, therefore, their load-carrying requirements must be considered under conditions of high horsepower — high torque, and high horsepower — low torque.

High horsepower — high torque conditions

A transmission must be able to absorb engine torque multiplied by the transmission gear ratio.

A rear axle must withstand engine torque plus torque developed from the transmission gear reduction.

As an example of determining load requirements under high torque conditions, let us take a typical truck engine, transmission, and rear axle with the following specifications:

Engine Torque: 385 lb-ft

Transmission Reduction:
First — 8.08/1
Second — 4.67/1
Third — 2.62/1
Fourth — 1.38/1
Fifth — 1.00/1

Axle: 21,000 lb rating spiral bevel of 6.5/1 ratio.

From the foregoing the tooth loadings are obtained as shown in Table 1. From highway operation it is known that a 5-speed transmission with the fifth

Table 1 — Transmission and Rear Axle Tooth Loads

Transmission Reduction	Transmission Tooth Load, lb/in. face	Rear Axle Tooth Load, lb/in. face	Rear Axle Over Transmission Tooth Load Increase, %
8.08/1	7330	13,625	85.8
4.67/1	5070	7875	55.3
2.62/1	2500	4420	76.8
1.38/1	1960	2330	18.8
1.00/1	0	1690	—

lubricant compared

Table 2 — Time Spent in Various Gears with 5-Speed Transmission

Gears	Time in Gears, %
1	2
2	3
3	10
4	25
5 (direct)	60

direct, operates in the various gears the percentage of time shown in Table 2. The two tables make this apparent — **the rear axle lubricant must be able to absorb greater torque or provide better load-carrying qualities than a transmission, especially in the first three gears. Even though operation is only 15% in these gears, that's when gears are destroyed if the lubricant lacks extreme-pressure qualities.**

In off-highway operation the first three gears are used 50% of the time, making e-p lubricants for the rear axle even more essential.

Under shock loading at any time, rear axle tooth loadings will rise sharply. If such loading is too frequent or severe, even e-p lubricants can't prevent ring gear or pinion tooth failure.

High horsepower — low torque conditions

Under conditions of high horsepower and relatively low torque, mineral oil will attain results comparable to those with an e-p lubricant.

This fact was brought out by 5-hr dynamometer tests of a 16,000-lb capacity spiral bevel axle of 4.875/1 ratio, using mineral oil and e-p lubricant. Here the output horsepower was 124.6 and the ring gear tooth load was 1410 lb/in. face. There was no scoring or scuffing of ring gear or pinion tooth surfaces with either lubricant. The mineral oil reached a maximum temperature of 145 F, the e-p lubricant reached 139 F.

Past experience, particularly in fleet operation, shows that spiral bevel ring gear tooth loads in excess of 2000 lb/in. face in direct transmission gear operation will result in early tooth failures even with the best e-p lubricant. Loads must be kept below that figure to get optimum performance from the lubricant.

Operating temperatures

In highway operation a transmission will attain a temperature of 180 F while axle temperatures in spiral bevel gears will reach 170–180 F when ambient temperature is above 60–70 F.

In off-highway service a transmission will operate at 225–240 F with axle temperatures remaining about 170–180 F. Sometimes axles run cooler in off-highway than in highway service. The transmission temperature exceeds that of the axle because of the high torque at relatively low speed and because of the reduction in airflow.

Close correlation of axle and transmission temperatures in highway service is attributable to the predominant direct gear operation where transmission loads are zero and rear axle tooth loads are 1600–1800 lb/in. face. Airflow also helps to stabilize temperatures.

Rolling and sliding velocities

In transmission gearing (essentially of the helical and spur geartypes) and in rear axle spiral bevel gearing, sliding and rolling velocities are about equal. Nevertheless, the difference in tooth loading between transmission and axle gears makes e-p lubricants essential for rear axles.

When the pinion is moved from the ring gear centerline, the result is hypoid gearing, and sliding velocities then exceed rolling velocities. Hypoid axles require the finest e-p lubricant because the higher sliding velocities increase frictional forces, resulting in higher operating and tooth surface temperatures.

Lubricant properties

Bushings and journals in transmissions will fail if inadequately lubricated. Bushings and thrust washers in rear axles are less critical, but in both instances the lubricant must be compatible with bronze bushings.

Bushings and bearings in both transmissions and rear axles must be protected from rust and corrosion and the anticorrosion properties must meet the higher temperatures of transmissions.

Foaming occurs with both transmissions and axles. Defoaming agents will solve this problem, but they must be of the highest quality.

To order Paper No. 192C . . .
from which material for this article was drawn, see p. 6.

Airlines don't want Mach 3+

Mach 2 aircraft must come first

Here, the chief engineer of an airline talks back and tells bluntly why he thinks Mach 3+ transports are pie in the sky.

He issues a clarion call to the airlines to collaborate with manufacturers NOW to get what they want instead of what is available.

Based on paper by **B. S. Shenstone**
British European Airways

THE AIRLINES are being told by several manufacturers that the only thing to buy is the Mach 3 or 3+ airliner. Why this number? Was it chosen for or by the airlines? It was not. No airline engineer wants it.

One of the big points made is that the One True Economy, the balance between bad L/D and good specific fuel consumption, occurs at Mach 3 or a little higher. This I do not believe, considering the data available. It is a matter of assumptions and thickness of lines and hunches and has no true engineering validity. The hump at Mach 1 certainly occurs and thereafter things get better. But when reaching into the unknown it is difficult to sight along the curves with any confidence, as they are so diffuse and woolly. With no great technical ingenuity one can show the best economics to occur anywhere from Mach 1.3 to 3.5, so let's forget the special magic of Mach 3+. Mach 3+ as an idea may well have arisen through military/commercial competition; that is, through fear. The struggle to show economy may have come later.

Constant progression is aim

Airlines are conservative. Whenever, in temporary aberration, they cease to be, they regret it. They have to be conservative to stay in business and this conservatism (scarred by early wildcat ventures) includes fostering all developments likely to increase business.

One of the basic experiences of airlines is the need for constant progression, not sprinting or pole-vaulting. Let's consider speed. Successful airlines have thus far increased speed, as one type succeeded another, by not more than 30–40% at a time. Fig. 1 shows this almost constant progression through the DC-Series, beginning with the DC-3. Other series aircraft transcribe a similar curve.

The ratio F, which is the speed of the new type as the ratio of the speed of the type it replaces, is drawn for the value of 1.4, on the assumption that each new aircraft type is 40% faster than the last one. The curve is slightly optimistic, but what does it matter when the next type is to have a value of 3.6? For the sake of good sense, aircraft speeds of Mach 1.3, 2.3, and 3.3 are shown as they lie with respect to the curve if each is considered as replacement aircraft. It shows Mach 3+ to be a major aberration. The curve is shown on a linear speed scale so that nobody will get the idea that $F = 1.4$ is grossly conservative.

Too much, too fast

How are the airlines to swallow at one gulp a 350% increase in speed and, in achieving it, deal with problems of fundamental nature in structures, aerodynamics, operation, and air traffic control and not go broke? It is, bluntly, nonsense. You may retort that the old-fashioned increment of 40% can no longer work because of the Mach 1 hump. Forty per cent more than 600 mph is 840 mph, or about Mach 1.3. Military data and research on economics have shown that good aircraft, usable aircraft, can be made for Mach 1.3.

It must not be forgotten that the aerodynamic jump between the subsonic and Mach 2, and even between Mach 1.3 and Mach 2, is enormous. The classical aircraft is done for. Any attempt to retain features of the classical aircraft at such supersonic speeds is a mistake, and this includes the use of the long, circular-section separate fuselage. It is astonishing to me that so many of the tenative proposals made in the literature are combinations of thin

transports

if airlines are to stay in business.

wings, swept or unswept, and the long, cigar-shaped fuselage. Elementary considerations readily expose the necessarily inferior aerodynamic properties of these concepts.

What about the engine?

It is perhaps over the problem of the engine for Mach 3 that airlines are most disturbed. The engines will have to be entirely new to obtain the efficiencies needed, and in particular the intake problem is very difficult, even at Mach 2. There are unsolved problems of temperature and fatigue in the Mach 3 engine, the solution of which may well increase costs considerably. In some of the assumptions made in the literature, the engine has been assumed to cost no more to buy or overhaul than existing turbojet engines. I think this is highly optimistic. These engines will have to withstand very much higher intake temperatures and, although mechanically they may be somewhat simpler than present-day, two-spool, bypass engines, they are bound to be more expensive to buy because of the exotic and expensive materials they will have to use to withstand the temperatures. And as a result they may have an inherently lower overhaul life. Since airlines will demand at least as good an overhaul life as at present, the attainment of this may make the engine even more expensive to buy, or alternatively, more expensive to overhaul because of a high rate of parts replacement.

On the other hand, Mach 2 requires only an acceptable extrapolation for the engines, the main problem being efficient intake design.

What's the hurry?

People are now saying: "Although someone could produce Mach 2 for service in, say, eight years, in a few years more the Mach 3+ could be built and run the earlier machines off the map." These figures imply orders given now, and if you fall for that you show your age. If I were an airline and had chosen to order a Mach 2 transport and my competitor had decided to order Mach 3, I would be the happiest airline in the world because I would know from all the research done to date that I would have years and years of operation without serious competition.

You will gather that I suspect that Mach 3+ aircraft will be found to be unsatisfactory if it is taken in one jump. So we shouldn't jump. None of us can afford to bring any supersonic aircraft into service before the early 1970's. But I suggest that even if you reach no further than Mach 2, airlines should now begin to collaborate with manufacturers while there is still time for airlines to get what they want instead of having to take what is available.

To Order Paper No. 166A . . .
from which material for this article was drawn, see p. 6.

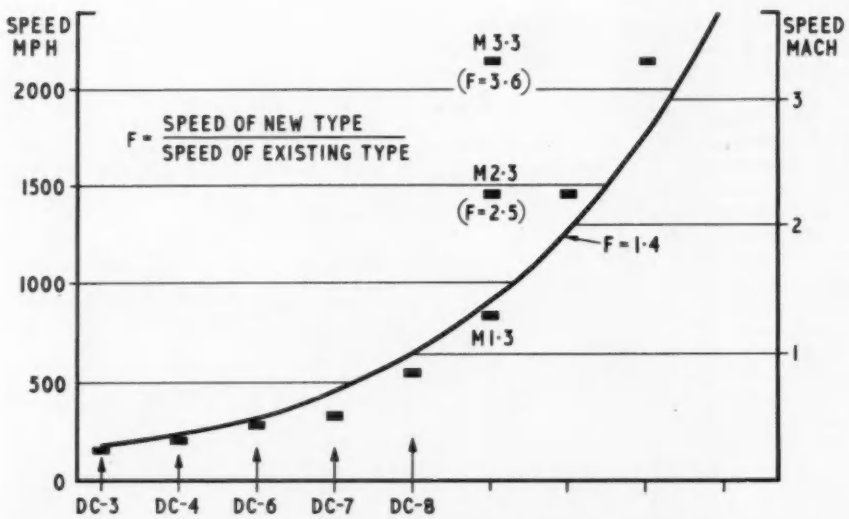

Fig. 1 — Each new model in the DC series has been about 30 to 40% faster than the preceding one, and this is true of other series of aircraft. The *F* ratio, drawn for the value of 1.4, shows the Mach 3+ aircraft to be an aberration.

Controlling noise in unitized-body

Based on paper by **F. R. Kishline**
American Motors Corp.

NOISE is the least predictable factor in the design of suspensions and their attachments to unitized bodies, but it can be controlled by varying both isolation and tuning. Moreover, the amount of insulating material needed to silence unitized cars is no greater than that needed for body-to-frame cars.

Front suspension

Road noise, tire thump, and tire roughness are the principal noises influenced by front suspension design, and all three are interrelated to some extent with tire carcass resonance. Hence, the suspension should provide high attenuation of frequencies in the range of tire carcass resonance. These fall within the normal 25–250 cps range of road noise frequencies.

In theory, isolation could be obtained by lowering the natural frequencies of the unsprung mass in all directions to well below the tire carcass resonant frequencies. But this is impractical because the flexibility in lateral translational and rotational modes would be intolerable for steering and handling. The answer is to isolate the lower control arm supporting member from the body structure, as shown in Fig. 1. This provides high lateral stiffness for good handling as well as adequate flexibility both vertically and longitudinally for good noise isolation. In addition, a two-stage filtering action is gained by interposing the cross-member mass between the unsprung mass and the body structure.

Experience with fully isolated suspensions in which springs, shock absorbers, and upper and lower control arms are contained in a single unit have shown the benefit in noise reduction to be more than offset by increase in weight, cost, and space requirement.

The front suspension coil spring seats against the upper wheelhouse structure with a thin rubber insulator at each spring end, as shown in Fig. 2. The gain from using spring seat insulators with as much as $\frac{3}{8}$-in. static deflection has not justified the added cost and complications.

Rear suspension

Noises contributed by road, tire, axle gear and bearing, driveline, and engine torque reaction must all be considered in a rear suspension system design.

We have found the torque tube drive rear suspension with coil springs to be superior to other types in noise reduction. Rear wheel road noise, transmitted through a torque tube suspension, is negligible compared to that from the front wheels, primarily because of the isolation of the rear axle in fore-and-aft direction afforded by the engine mass on relatively soft mounts to the body (Fig. 3). Very little axle noise enters the body via engine mounts.

Coil springs do tend to resonate in complex patterns in the frequency range of axle noise, but isolation beyond thin rubber pads to break metal-to-metal contact achieves little. The remaining mechanical noise path is through the transverse track bar, which can be tuned to some degree by changing its mass or stiffness. The driveshaft sometimes resonates torsionally when excited by axle gear tooth contact, resulting in an axle noise period. Such periods can be tuned out of the operating speed range by using a driveshaft which is part solid, part tubular, having the desired torsional stiffness.

Hotchkiss suspension

The Hotchkiss suspension can produce very acceptable results in a unitized car if it is carefully tuned. It is lighter and cheaper than the torque tube

Fig. 2 — Front suspension coil springs are insulated at both ends with a thin rubber ring. The insulated spring, as shown, seats against the upper wheelhouse structure.

through suspensions

cars

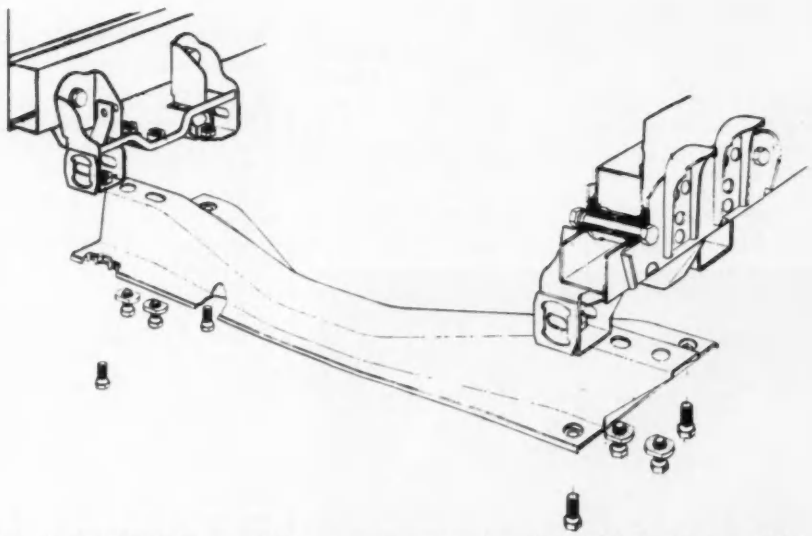

Fig. 1 — Isolating the lower control arm supporting member from the body is both effective and efficient front suspension design for reducing noise in a unitized body.

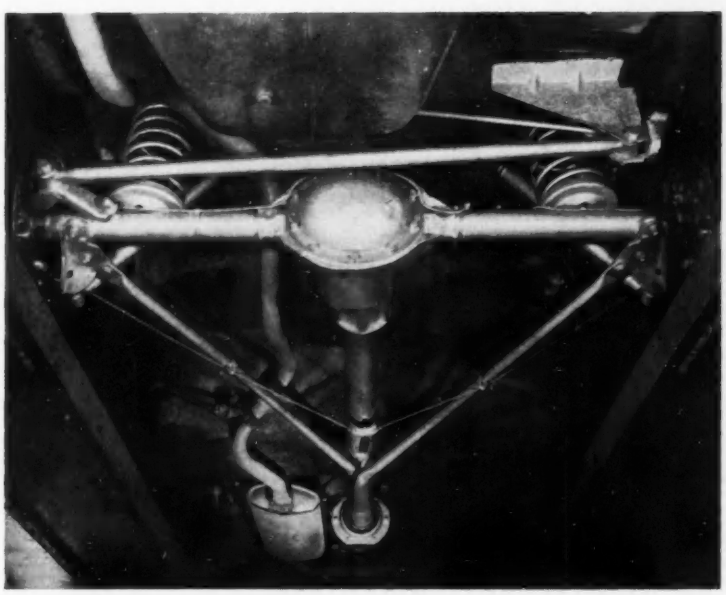

Fig. 3 — Rambler torque tube rear suspension with coil springs showing mounts to the body.

suspension, but these advantages can easily be tossed away through elaborate isolation systems, complicated driveshafts, and inefficient spring design resulting from efforts to reduce noise.

Curing noise problems

Illustrative of the complexities in tuning a suspension for a unitized body is an experience had when developing the Hotchkiss suspension for the Rambler American. The car had a "boom period" at 25 mph caused by engine firing frequency exciting a body floor pan resonance. It defied a satisfactory solution through clutch damper tuning, engine mount stiffness, rear spring rate or damping, or modification of floor pan stiffness. The solution was to put a slot in the pan across the tunnel immediately ahead of the cross-member to which the rear spring front eye brackets are attached. This slot, its length determined experimentally, allowed the rear portion of the pan to vibrate out of phase with the front portion, thereby cancelling the noise generated.

Axle gear noise is hard to isolate from the body with Hotchkiss suspension. Tuning and/or damping

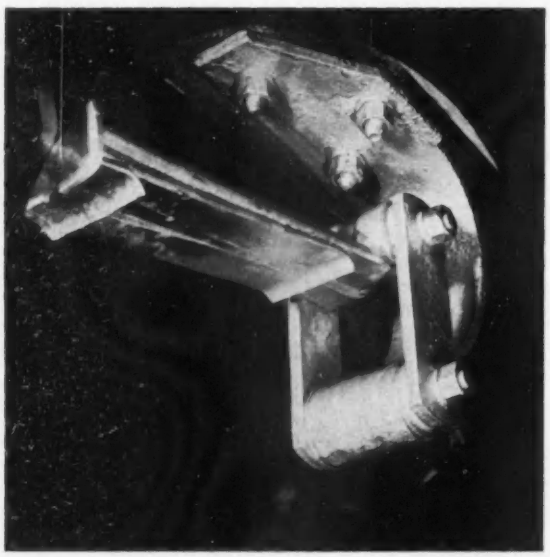

Fig. 4 — Tension rear spring shackle with flexible hanger used on the Rambler American contributes to reduction in axle noise.

is more effective than isolation. It was found that spring resonance excited by axle noise can be damped effectively by using ordinary cardboard as interleaf friction material. Still better, and now in production use, is a plastic impregnated fiber board which is durable, weather resistant, and has frictional stability.

Also effective in reducing axle noise is the use of a tension-type, rear spring shackle with experimentally determined flexibility in the spring steel shackle hangers (Fig. 4). The combination of tension shackles, spring leaf damping, and selection of optimum spring eye bushing stiffness resulted in virtual elimination of axle noise periods, reduced road noise, and acceptable ride and handling.

To order Paper No. 143A . . .
from which material for this article was drawn, see p. 6.

Choice of MATERIALS

High-Temp,

Based on paper by

William J. Anderson and Edmond E. Bisson
Lewis Research Center, National Aeronautics and Space Administration

MATERIALS compatibility is a major factor in the successful operation of high-temperature, dry, roller-element bearings. It is also important to get the right design and limit both loads and speeds.

Very satisfactory results have been obtained with a bearing having balls and races made of M-10 tool steel and ball spacer buttons formed from graphitized carbon with an organometallic impregnant. This design and choice of materials is based on the principle that the cage should be constructed so that carbon is used at all the rubbing contacts without forcing it to carry all the cage loads because graphitic carbon compacts are generally low in mechanical strength, especially in tension.

This bearing ran successfully in an air atmosphere of 1000 F at thrust loads up to 105 lb and speeds of 2430 and 5024 rpm. Ball and race wear were nil after 3 hr of operation. The shape of the torque curves is shown in Fig. 1A. It indicates that the 105-lb thrust load is probably close to the limit for this cage configuration. Fig. 2 shows there was some chipping of the ball spacer buttons and concave wear depressions of the button ends contacting the balls. Torque curves at 2430 and 3480 rpm and 1000 F for a similar bearing fitted with a two-piece machined cage of the same graphitic carbon is shown in Fig. 1B.

Results with other cage materials

Test runs were also made with a cage material machined from a special iron-base alloy, which exhibits coefficients of friction of less than 0.1 in sliding against itself and against certain other alloys at 1000 F. The torque data shown in Fig. 1B were obtained at lower speeds than those for the carbon-cage bearings, but the shape of the torque curve indicates better performance at higher loads.

A dramatic illustration of the importance of material is afforded by a cage of this iron-base alloy in a bearing with races of Stellite 19 and balls of Stellite 3. Successful operation could not be had even at zero load. Fig. 3 shows the outside diameter (locating surface) of a cage run against Stellite and a cage run against M-10. There is severe surface welding and material transfer after sliding against Stellite.

Fatigue problem at high temperatures

For use in roller-element bearings, tool steels must be clean, that is, free from inclusions or dirt stringers which can influence fatigue adversely. Some of the

is all important for success with

Dry Bearings

early fatigue data on bearings made from molybdenum-base tool steels indicated a poorer fatigue life or, equivalently, a lower load-carrying capacity than that for SAE 52100 at room temperature. There is also data showing further reduction in fatigue life for air-melted heats of molybdenum-base tool steels at 450 F and at temperatures up to 500 F. More recent available data show marked improvements in fatigue life with improved melting techniques, such as induction and consumable-electrode vacuum melting. They also show fatigue life comparable to that of SAE 52100 at room temperature to be obtainable at 450 F with clean, vacuum-melted heats of tool steels.

Material hardness also affects fatigue life. Reference can be made to room-temperature, fatigue data for three molybdenum tool steels and a new alloy, known as WB-49, developed by the Crucible Steel Co. which indicate that the higher the hardness the better the fatigue life. WB-49 shows promise for applications up to 1000 F, where retention of hot hardness for periods up to 1000 hr is required.

Ceramics offer possibilities

Experiments with rolling-element bearings made from tungsten carbide have shown questionable success. And some success has been reported with titanium carbide. Materials of this type may be suitable for some applications.

The NASA has conducted some experiments on the fatigue life of crystallized glass ceramic balls (Pyroceram 9608) in a five-ball fatigue tester. The load-carrying capacity was found to be approximately 1/15 that of a group of AISI M-1 steel balls. Weibull plots resulting from fatigue tests at both room temperature and 700 F showed fatigue at 700 F to be about ⅓ that observed at room temperature. This may not indicate a thermal effect in the bearing material itself; thermal effects on the test lubricant (a highly refined mineral oil) over this temperature range could produce the difference in life.

The rate of failure spall development in Pyroceram 9608 was much slower than is normal for steel balls. The scatter between short- and long-lived specimens was also much lower for the ceramic than is normal for bearing steels. This result indicates that the degree of structural homogeneity may be an important factor in life scatter of bearing materials. The crystallized glass ceramic has a crystal structure much the same as bearing steels, but the crystals are extremely small and the structure is more homogeneous.

To Order Paper No. 176D . . .
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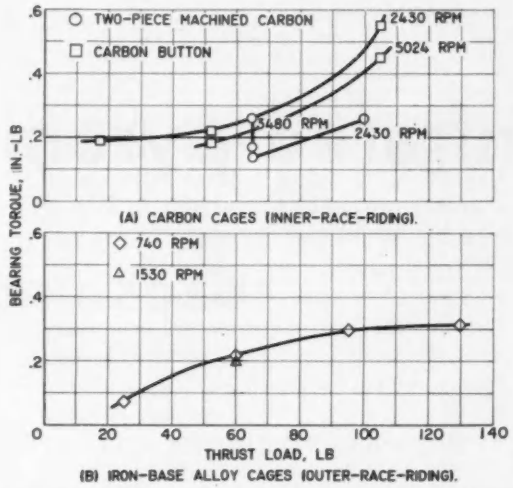

Fig. 1 — Performance of 204-size, M-10 tool-steel ball bearings running dry at 1000 F with two types of self-lubricating, carbon cages.

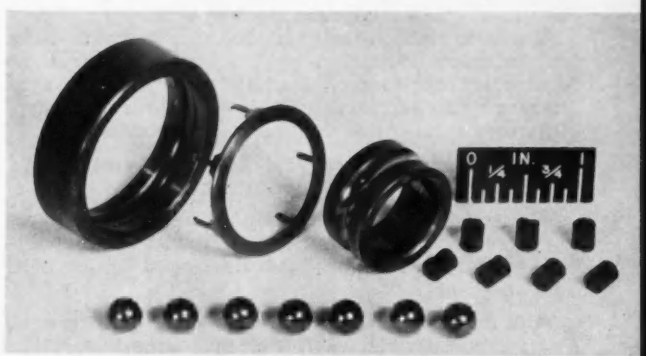

Fig. 2 — Disassembled M-10 tool-steel bearing with carbon button ball separators shows some chipping of the buttons and concave depressions at the button ends from contacting the balls. Ball and race wear was nil.

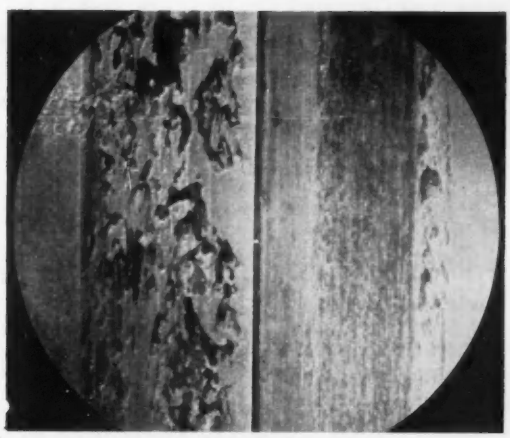

Fig. 3 — Comparison of surface damage sustained at cage locating surface by an iron-base alloy cage run against two different materials at 1000 F illustrates the importance of material selection. (Left) after sliding against Stellite 19; (right) after sliding against M-10 tool steel.

Infrared pyrometer

reads engine gas temperature

AN INFRARED PYROMETER, utilizing water vapor as the sensing medium and the null method of data recording, is capable of measuring gas temperatures under ideal conditions within ± 5 deg R, and in an engine within ± 20 R. The gas temperature of a nonisothermal layer of gas can also be measured, but its meaning is subject to the nature of the boundaries.

These are among conclusions drawn from using an infrared radiation pyrometer (developed at University of Wisconsin under CRC auspices) to measure gas temperatures in the three following different combustion-chamber configurations:

- A modified 7-hole CFR head used during the instrument development phase
- A specially pocketed combustion chamber constructed by MIT in connection with their sonic-velocity technique (also developed under CRC auspices).
- A modified L-head combustion chamber used for comparison tests with an iodine-absorption pyrometer (also developed at University of Wisconsin under CRC auspices.)

In these tests with the infrared pyrometer, fuel and airflow were metered by a flowmeter and critical-flow orifices, respectively, and mixed in a steam-jacketed tank before entering the engine. Inlet pressure was controllable over a wide range . . . and exhaust pressure was held at one atmosphere. Cooling water in the jacket was controllable in the range from 60 F to 210 F.

To measure the compression gas temperature by the null method, the engine was instrumented as shown in Fig. 1.

More conclusions

Conclusions drawn from the extensive data taken by the infrared pyrometer to evaluate the instrumentation and recording method also included the following:

- Reproducibility of the measured gas temperatures depends on the density of the water vapor in the measuring zone . . . and on the overall sensitivity of the infrared pyrometer. Water vapor normally present in the intake and clearance gases of the engines are sufficient to give reproducible readings within ± 20 deg R, using the null method of recording data.
- The infrared pyrometer, when measuring the apparent temperature of a volume of gas in an engine, measures a temperature weighted toward the peak temperature of the gas, whereas the sonic-velocity instrument measures a gas temperature weighted towards that of the mass.
- Comparative engine data, using first the iodine-absorption pyrometer and then the infrared pyrometer, show that gas temperatures measured by the former technique had a "humped" characteristic which was not evident in those measured by the infrared pyrometer. Exhaustive tests of the iodine-absorption pyrometer did not resolve the differences between the comparative gas temperatures. Thus, it was reasoned that the iodine molecules were not in apparent thermal equilibrium with the other gases in the combustion chamber.

The infrared pyrometer

The infrared pyrometer is the third instrument capable of measuring gas temperatures in an engine to come from the work of the Subcommittee on Fundamentals of Detonation of the Coordinating Research Council.

Earlier, under CRC sponsorship, a sound-velocity method of measuring these temperatures had been developed at Massachusetts Institute of Technology; and an iodine-absorption pyrometer at University of Wisconsin.

This infrared radiation pyrometer is made up of the components shown schematically in Fig. 2. Radiation from the hollow cavity of the source passes through the sapphire windows and through the gases in the engine chamber to a quartz lens which focuses the radiation on an infrared-sensitive detector.

An interference filter placed between the lens and the detector restricts the radiation falling on the surface of the detector to a wave-length band from 2.5 to 2.9 microns (10^{-4} cm). Since the transmitted wave-length band corresponds to emission-absorption bands of water vapor and carbon dioxide, radiation from those gases is transmitted to the detector, along with a portion of the source radiation.

To order Paper No. 201E . . .
from which material for this article was drawn, see p. 6.

to ± 20 deg R

M. C. Burrows, National Aeronautics and Space Administration; S. Shimizu, Nagoya University, Japan; P. S. Myers and O. A. Uyehara, University of Wisconsin . . . reported recently on a third instrument capable of measuring gas temperatures in an engine to spring from the sponsorship of CRC's Subcommittee on the Fundamentals of Detonation. This article briefs some of their findings.

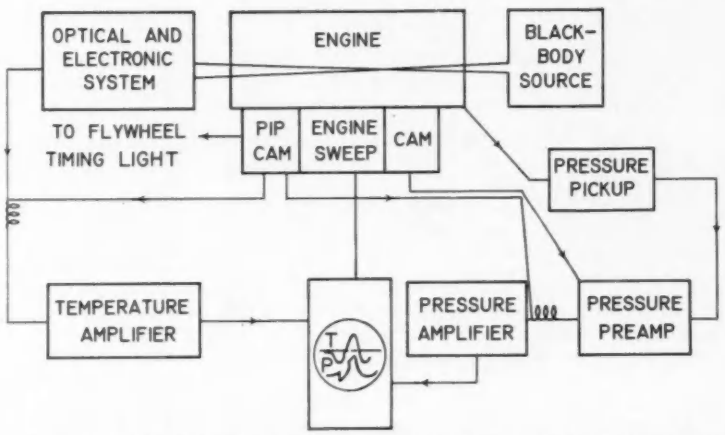

Fig. 1 — Block diagram showing instrument setup with infrared radiation pyrometer used to measure gas temperatures in engines.

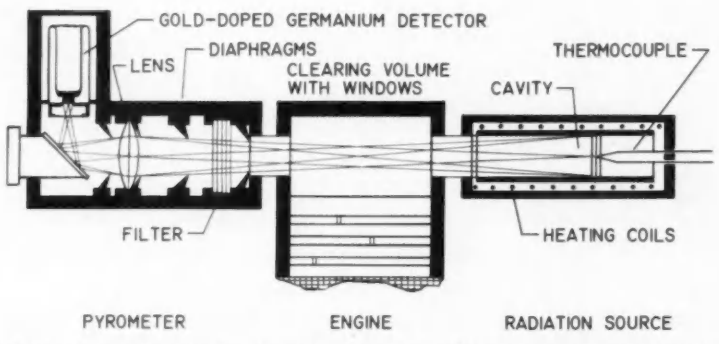

Fig. 2 — Components of infrared radiation pyrometer used to measure gas temperatures in engines.

Practical uses expanding for

High-Temperature Gas Carburizing

Test case shows potentials. Economics involve temperature, case depth, heating-cooling time, and net-to-gross furnace load.

Based on paper by **Orville E. Cullen**
Surface Combustion Division, Midland-Ross Corp.

PRACTICAL POSSIBILITIES of high-temperature gas carburizing are currently being explored by a number of different investigators. Studies now being carried on by different experimenters are confirming the belief that high-temperature gas carburizing has two major practical potentials:

1. An operating temperature of about 1800 F usually results in optimum efficiency from the production standpoint.
2. A minimum total case depth of about 0.075 in. is required to show worth-while economic advantages over 1700 F carburizing.

These potentials are well illustrated by study of a reasonably average case in which were recognized and utilized the techniques which are so pertinent to good results when high-temperature carburizing is used.

In this fairly typical case, a heat-treatment specification was presented which called for carburizing SAE 1022 steel gears at 1850 F. The specification included holding the surface carbon concentration at $0.95 \pm 0.67\%$ carbon and a total case depth of 0.075 in.

That the problem of surface carbon control can be kept well in hand during high-temperature carburizing is illustrated by Fig. 1. This shows a case-depth carbon-concentration curve obtained from a test bar run through a furnace on a trayload of production test gears which were carburized to meet this specification.

The type of carburized case represented by the curve is indicative of results obtained by using the "carburize-diffuse" technique.

This is in keeping with the most acceptable method now used at 1700 F. The optimum depth relationships between hardenable case and total case must be maintained even though the ultimate maximum allowable carbon content of the case is well below the solubility limit. To do this, the furnace atmosphere must be held at a high carburizing potential for a time, followed by control at a lower or diffusion potential to finally establish the specified surface carbon.

This particular test program specified lowering the temperature to 1650 F and equalizing, followed by aircooling to room temperature. The final heat-treatment is induction hardening of the tooth areas.

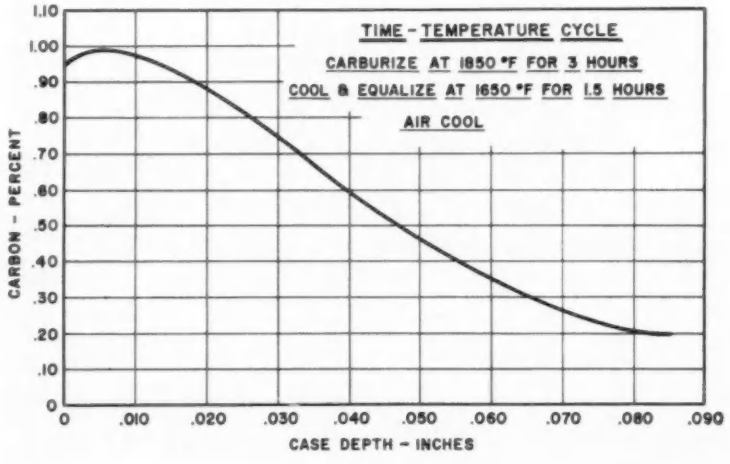

Fig. 1 — This case-depth carbon-concentration curve shows that surface carbon can be controlled during high-temperature carburizing.

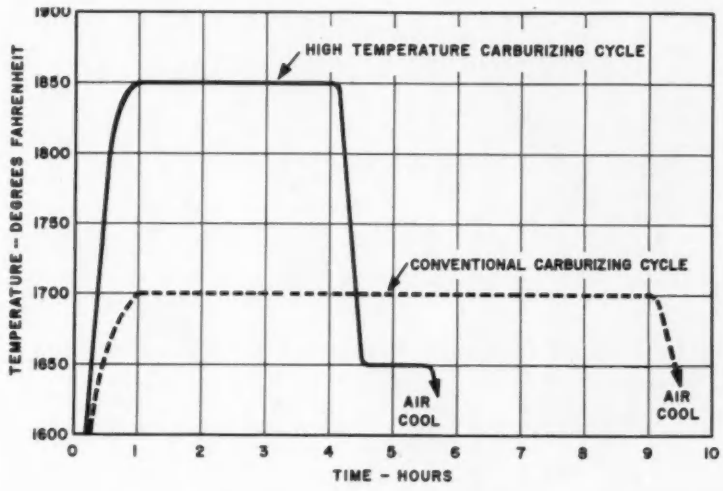

Fig. 2 — Broken-line curve in this time-temperature cycle shows the approximate cycle required to duplicate the results at a maximum temperature of 1700 F.

This specified treatment permitted taking advantage of rapid rates of carburizing at 1850 F in the high carbon potential atmosphere, followed by diffusion in an atmosphere of lower carbon potential during cooling to, and equalizing at, 1650 F. The time-temperature cycle is shown in Fig. 2. For an interesting comparison, the broken-line curve in this figure shows the approximate time cycle required to duplicate the results at a maximum temperature of 1700 F.

The photomicrographs in Fig. 3 shows the case and core of the SAE 1022 steel following the carburizing and cooling described above. The case and core of this material show mixed grain size with some duplexing. It was the opinion of processors of these gears that 3 hr carburizing at 1850 F exerted no unduly bad influence on the grain size of this material as compared with 1700 F carburizing.

In subsequent production load tests, gears made of SAE 1024 and of a modified SAE 1024 were carburized to the same specifications with similar results. After hardening, all these gears successfully passed the physical and mechanical tests regularly applied after 1700 F carburizing and surface hardening.

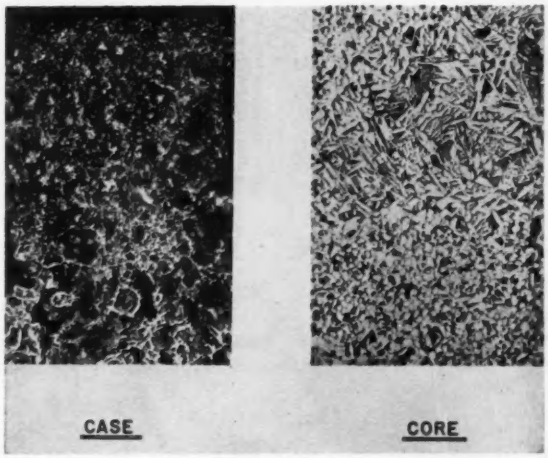

Fig. 3 — Case and core of SAE 1022 steel following the described carburizing and cooling cycle.

Perspective on tests

The manufacturer who made these tests made them on a relatively small percentage of his total carburizing production. He had to carburize and test a variety of different steels, including SAE 4027, 4620, 4815, 5120, and 8620. Case depths of this variety of steels run from about 0.045 in. to about 0.100 in., read to original carbon . . . and some of the carburized parts are aircooled and reheated. Others are direct quenched after lowering the temperature of the work to 1550 F. These latter are of special interest from the standpoint of metallurgical problems related to processing time at high temperature.

Economics of high-temperature carburizing

Growing out of the "average" case described and the experience of many other investigators, this manufacturer has concluded that the economics of the particular application should be determined early in the process.

The items relating to ultimate decision — assuming that suitable heat-treatment equipment is available — include:

- Temperature for carburizing.
- Case depth.
- Heating and cooling time.
- Net-to-gross furnace load.

Temperature and case depth will fix the time for carburizing . . . and this time will decrease as higher temperatures are used. Heating and cooling time will depend upon the geometry of the work and the character of the load. Also, it will change with the temperature of carburizing used.

The net-to-gross furnace load will generally decrease with increased temperatures . . . due to additional fixturing of the work and lighter loading because of natural decrease in strength of trays and fixtures.

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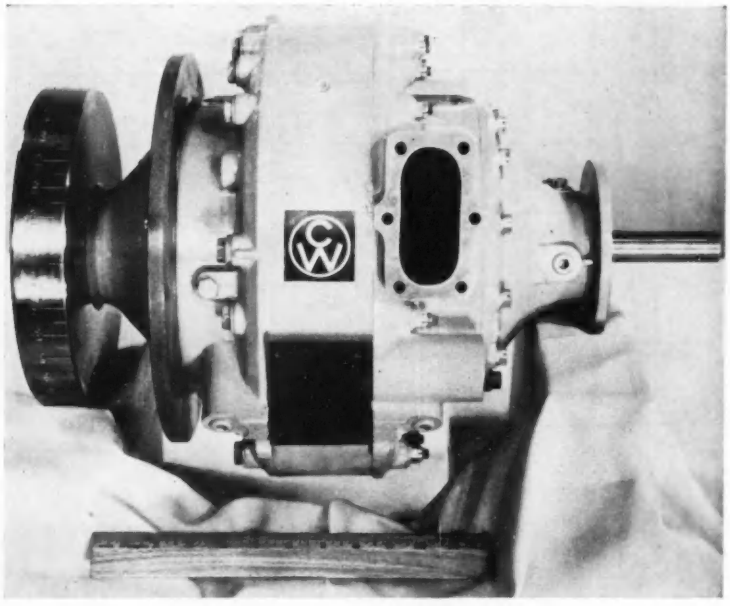

Fig. 1—Curtiss-Wright rotating combustion engine is a compact unit, small in both bulk and weight.

CW rotating combustion delivers 2 hp

Based on paper by

Roy T. Hurley

Curtiss-Wright Corp.

DEVELOPMENT of the CW single-rotor rotating combustion engine (Figs. 1–3) required the design of suitable systems for:

- Cooling.
- Ignition.
- Sealing.

This has been accomplished in the design of a series of 60 cu in. displacement experimental engines, which have been run for hundreds of hours in performance and durability tests, with no major failures. (See Figs. 4–11.)

Cooling

Liquid cooling has been used for both the housing and the rotor. The former is water cooled and the latter is cooled by lubricating oil pumped through the main shaft.

Housings — The rotating combustion engine, unlike a conventional reciprocating engine, always exposes the same stationary housing locations to the same portion of the cycle; the variation of heat input per unit of gas-exposed area along the trochoid periphery is shown in Fig. 12. To match this distribution, the housing cooling was designed as a multipass forced-flow system, as schematically illustrated in Fig. 13. The cooling liquid flows back and forth through the rotor housing and between the end housing walls. The rotor housing flow passages are parallel to the engine axis; the internal ribbing of the end housings redirects the flow, as shown in Fig. 14, where the trochoidal rotor housing is in position and the wear face of the end housing has been removed.

The flow area and wetted perimeter, and thus the hydraulic diameter, vary from pass to pass, and are adjusted to match the combustion cycle heat input

Material drawn from an
SAE Metropolitan Section Paper

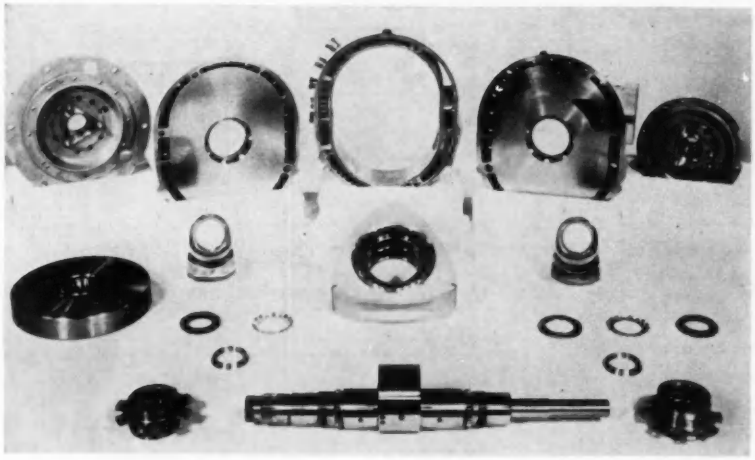

Fig. 2 — Components of engine.

engine

per cu in.

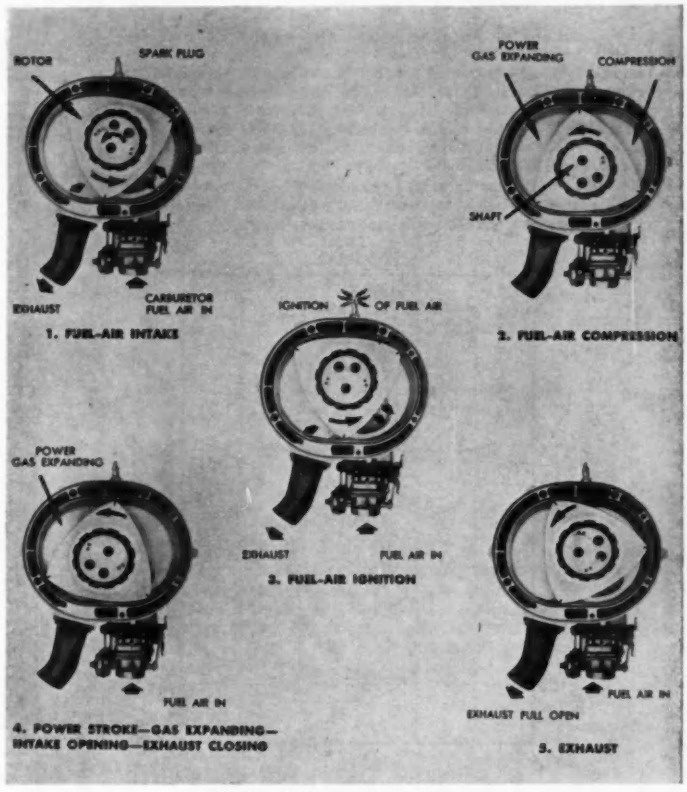

Fig. 3 — Cycle sequence of engine.

variation. For example, in hot regions of the engine, the flow velocity is high; the amount of heat transfer surface, accomplished by additional ribbing, is large; and the ratio of the total flow area to the total wetted perimeter per pass is small. This series forced-flow configuration permits balanced cooling with large, clog-free, easy to manufacture passages, and avoids vapor accumulation. Furthermore, the large passages permit a cooled wet-bolt application.

This system minimizes temperature variations of the housings. Thermal distortions are further restrained because of the type of structure employed: the outer walls of the housings run cold and maintain the designed shapes while permitting uniformly thin heat transfer walls. The locations of maximum heat input correspond to the locations of maximum stress, so that the addition of ribs, to improve heat transfer, serves to accommodate structural needs as well.

Rotor — The rotor is made from an aluminum

CW rotating combustion engine
... continued

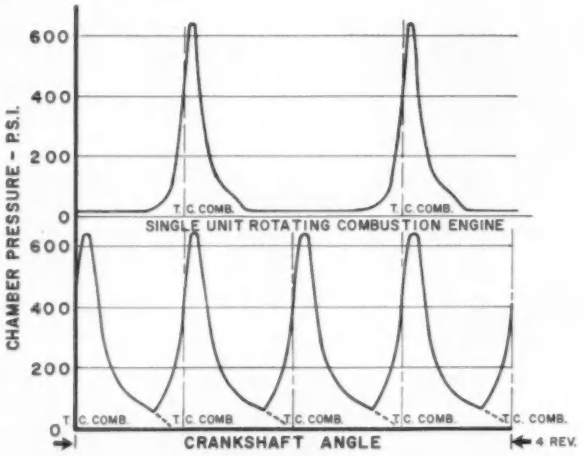

Fig. 4 — Cycle of single unit rotating combustion engine compared with that of a single-cylinder 4-stroke reciprocating engine. Chamber pressure versus crank angle is plotted for four revolutions of the crankshaft for each engine. Diagram shows that, during these revolutions, reciprocating engine has two power sequences, whereas rotating combustion engine has four. Note also that each power sequence of rotating combustion engine covers wider crank angle than is the case with reciprocating engine, ratio being 3/2.

Intake and exhaust flow both have shorter dwell periods for rotating combustion engine, thus reducing intake and exhaust losses and providing smoother operation, even for single power section.

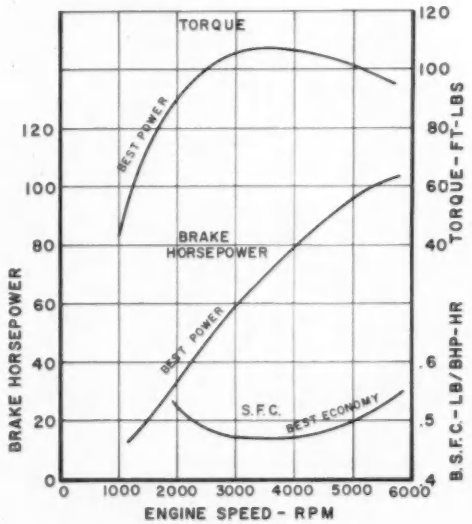

Fig. 5 — Full-throttle performance of engine equipped with side port intake. This engine develops 100 hp at 5500 rpm, which is equivalent to 1.67 hp per cu in. displacement. Output curve further shows that the port areas are not limiting factors. Torque curve is flat from about 2000 to 6000 rpm. At the lowest speeds, the torque drops somewhat, but this can be modified by other porting or by further development of the engine. In the initial development stages, attention has not been directed toward the low-speed torque end. However, test experience with porting configurations and satisfactory starting at very low speeds has indicated that improved performance in this regime can certainly be obtained if required for certain uses. Specific fuel consumption is also flat over a broad speed range, showing a minimum of 0.47 lb/hp/hr.

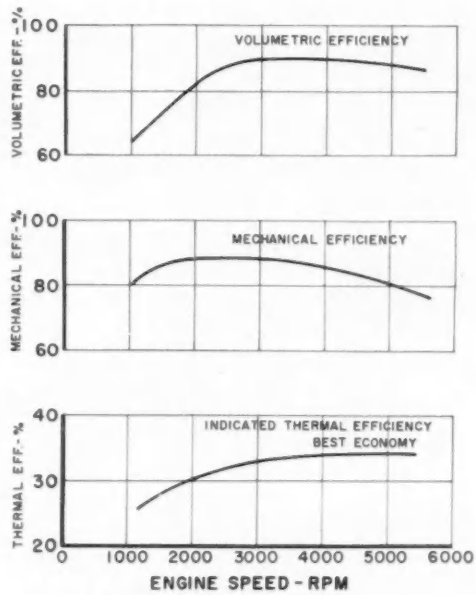

Fig. 6 — Volumetric, mechanical, and indicated thermal efficiencies at full throttle for engine equipped with side intake port. Consistent with the torque characteristic, volumetric efficiency is high over a wide speed range and reaches, with a side port intake, values of 90% and more. The mechanical efficiency also reaches almost 90% at the lowest speeds, indicating that the mechanical friction of the engine is low. The mechanical efficiency drops at higher speeds but this is expected to be improved with further development. It should be noted that, at 100 hp, the mechanical efficiency still is approximately 80%. The indicated thermal efficiency for best economy reaches 34% over a wide speed range.

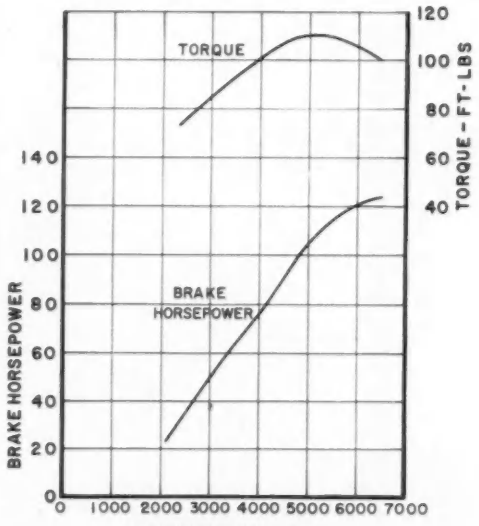

Fig. 7 — Full-throttle performance of engine equipped with peripheral intake port. This port further reduces intake losses and results in correspondingly higher airflow and output. Engine delivers 124 hp at 6500 rpm—equivalent to 2.05 hp/cu in., and again shows promise of further output increase with speed and some development. In the meantime, speeds up to 8000 rpm have been successfully run.

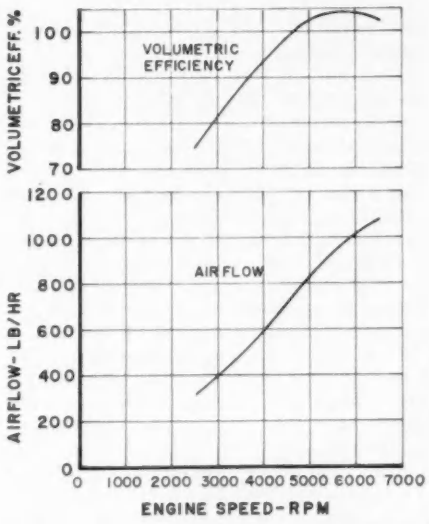

Fig. 8 — Volumetric efficiency and airflow at full throttle for engine equipped with peripheral intake port show high-speed characteristic of this engine, with volumetric efficiencies exceeding 100% and a steadily increasing airflow with speed readings almost 1100-lb/hr at 6500 rpm. At present, the peripheral port engine is slightly inferior with regard to air utilization as compared to the side port engine, which fact is reflected in a somewhat higher specific fuel consumption. This peripheral port configuration provides an excellent breathing capacity and it is believed that the engine will exceed the side port performance by a considerable margin.

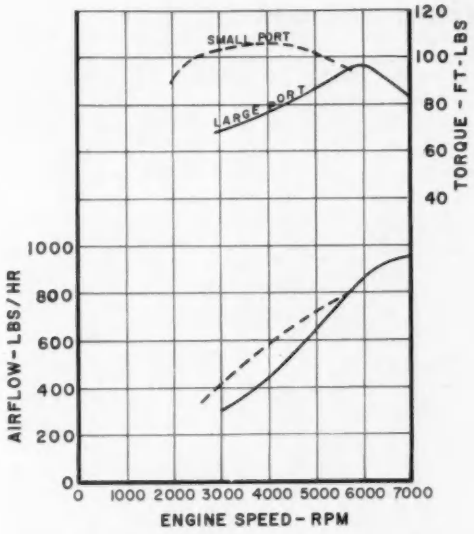

Fig. 9 — Full-throttle performance for engines with small and large side intake ports. Note that engine speed characteristics can be considerably varied and adjusted to different applications by port area and timing. Whereas the "large port" designated engine shows a peak torque of 95 ft-lb at 6000 rpm, the "small port" engine delivered —consistent with the airflow characteristic—105 ft-lb at 4000 rpm.

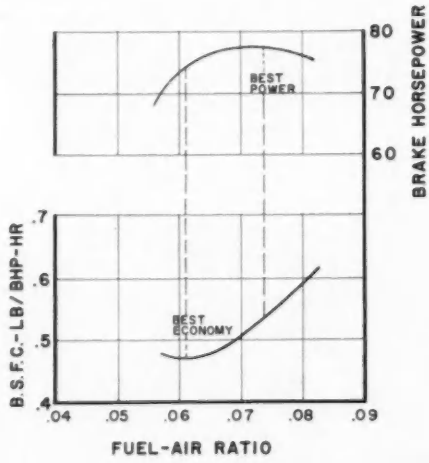

Fig. 10 — Power and fuel consumption shown as a function of fuel/air ratio for full throttle, constant speed (4000 rpm). Values of 0.061 fuel-air ratio for best economy and 0.073 for best power show good combustion characteristics in engine.

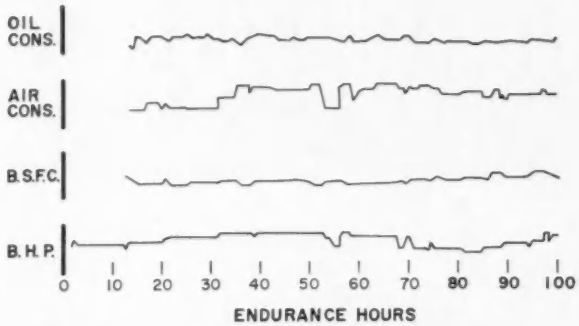

Fig. 11 — Endurance log — full throttle, rated rpm. Various engines were submitted to cyclic and full-throttle endurance runs. Note engine characteristics were very constant throughout whole test. Same consistence was achieved with cyclic endurance tests consisting of alternate periods of full throttle, full speed; part throttle, full speed; and reduced speed; and idle.

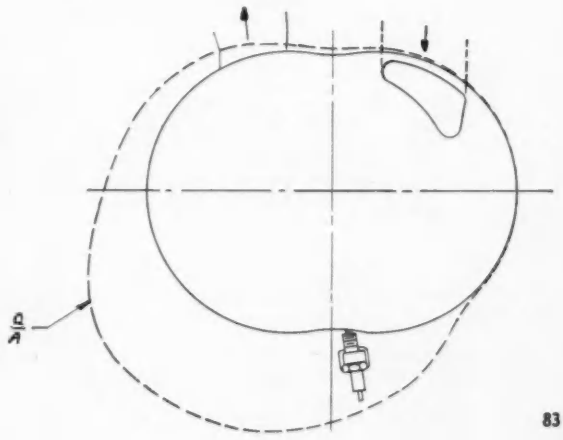

Fig. 12 — Polar plot of heat input per unit area.

CW rotating combustion engine . . . continued

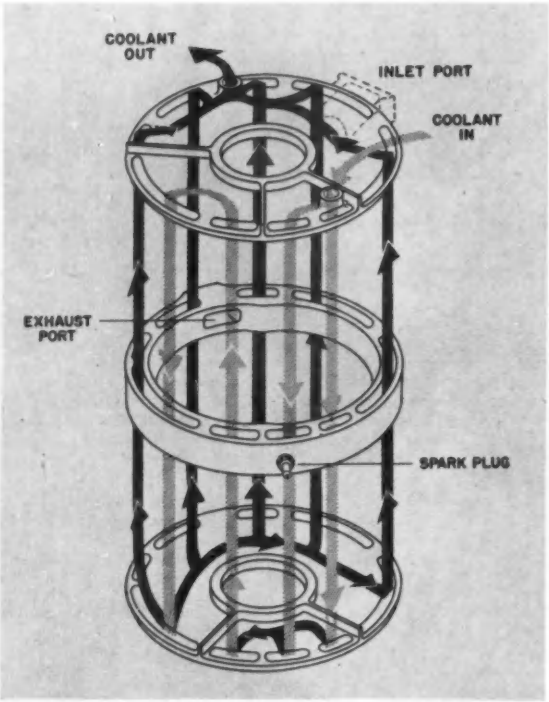

Fig. 13 — Schematic of housing cooling system.

forging, which offers the benefits of lightweight and high thermal conductivity, but requires adequate cooling.

One of the most successful aluminum rotor designs is cooled by forced circulation of oil from the engine lubrication system. The cooling circuit is schematically illustrated in Fig. 15. Oil is supplied from the hollow shaft, through radial feed holes in the eccentric, and then to the rotor bearing central annulus. The oil then divides, one part to lubricate the bearing and the other to cool the rotor.

Integral fins in each rotor lobe provide adequate cooling surface and a small hydraulic diameter. A recess at each end of these finned passes acts as a manifold for distribution of the oil.

The oil from the rotor exit, after passing the bearing end annulus, is discharged from timed shaft eccentric passages directly into the housing drain annulus.

The oil entering temperature, temperature rise, and period of contact with the metal are controlled to avoid coking or other lubricant deterioration. To date, we have had no evidence of adverse effects in this regard. While the oil flow of this design is continuous, the velocity varies as a function of the system dynamics: shaft and rotor inertia pumping superpose a roughly sinusoidal pressure increment onto the oil supply pressure. The cooling oil is metered at the exit; in this way, the rotor cavities are maintained full.

Whereas this aluminum rotor was designed and proved suitable for high-performance, high-speed operation, a nodular cast iron rotor has performed satisfactorily for less stringent conditions in this respect. This was achieved with a simpler cooling system and even with no internal oil cooling at all.

Ignition

Initial engine tests used automotive ignition systems and spark plugs of a normal automotive heat range. With increase in power and speed, it was

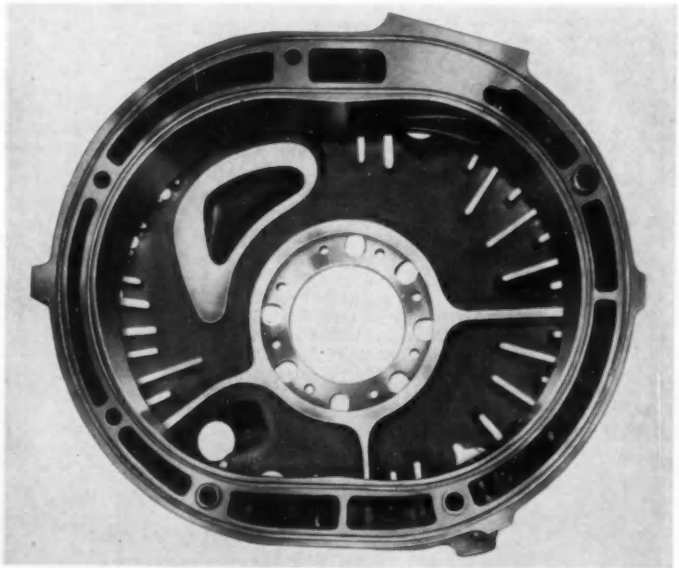

Fig. 14 — Internal ribbing of end housing redirects flow of cooling liquid, as shown above. Trochoidal rotor housing is in position and wear face of end housing has been removed.

found necessary to use a spark plug of very cold design for plug durability, and some plug fouling was then encountered. An auxiliary air gap at the spark plug reduced the fouling somewhat, but the periods between plug changes due to fouling and gap erosion were still not acceptable.

A Curtiss-Wright designed condensor discharge system, which produced a voltage rise rate four times that of an automotive system, reduced gap erosion and sensitivity to fouling deposits considerably. The plug change periods were increased four to ten times. With a still higher voltage rise rate, full power tests for 150 hr, cyclic endurance tests for 75 hr, and numerous general development tests with no cases of plug fouling and a very low gap erosion rate were accomplished.

The basic system is outlined in Fig. 16. A transistorized power supply charges the condensor. When the engine driven maker closes, the condensor discharges to ground, causing a surge of current through the coil primary. This surge generates a secondary voltage to fire the spark plug.

The coil is small and is designed to provide an adequate firing voltage even when loaded with a fouled spark plug.

The usual breaker system is modified to a maker and, at the same time, the dwell is much shorter to conserve d-c power. Due to the high voltage that is being switched, the quality of the contact surfaces need not be high to generate a reliable spark.

A standard distributor unit has been satisfactorily run for some 800 hr at 10,000 sparks per min. Timing drifted about 2 deg in the first 400 hr and about 1 deg in the last 400 hr. Point gap decreased about 4/1000 in. from the nominal 17 setting. Spark voltage was normal during this period and there was no tendency for the points to weld and stick.

Fig. 17 shows the plug voltage required by a large, conventional V-8 engine versus the requirement of the 1RC6 type in terms of sparks per minute. The rotating combustion engine requires a lower voltage over the operating speed range.

Sealing

The sealing system was originally copied from the small NSU-Wankel experimental engines. Although the bigger engine gave advantages in some respects, many of the sealing components were not durable enough and a more rugged system was worked out and incorporated in the rotor. This seal arrangement proved not only more durable but it was also tighter and very gratifying results were obtained with it.

To order Paper No. S236 . . .
from which material for this article was drawn, see p. 6.

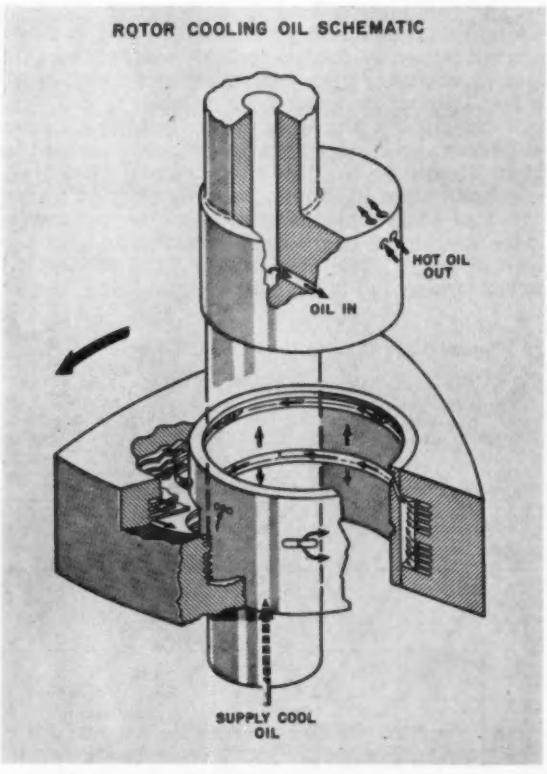

Fig. 15 — Rotor is coolel by forced circulation of oil from engine lubrication system. Oil is supplied from hollow shaft, through radial feed holes in eccentric, and then to rotor bearing central annulus. Oil then divides, one part to lubricate the bearing and the other to cool the rotor.

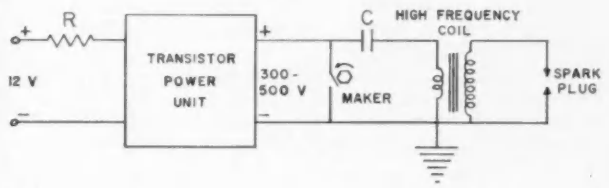

Fig. 16 — Condensor discharge ignition system.

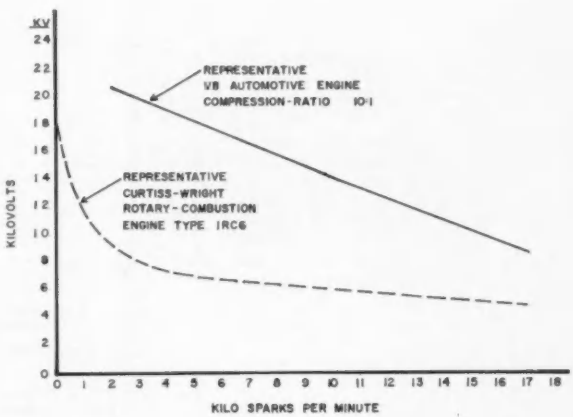

Fig. 17 — Plug voltage required by rotating combustion engine and also by large, conventional V-8 engine, in terms of sparks per minute.

Aircraft and missile alloys

▶ Metal-removal study indicates advantages

Based on paper by

Michael Field

Metcut Research Associates Inc.

AIRCRAFT and missile alloys are difficult and costly to machine. Many approach the hardness of conventional cutting tools, so that new machining techniques have to be used. This article reviews the relative machining properties of the aircraft and missile alloys and points out the limitations in machining.

The aircraft and missile alloys have been divided into eight groups, Tables 1, 2, and 3. The alloys within each group have similar machining properties which have been recently investigated.[1,2]

Applications and limitations of machining operations

In aircraft manufacturing, milling is probably the most widely used operation, followed in importance by drilling and tapping. In missile manufacturing the major operation is turning, followed in importance by drilling, milling, tapping, and grinding.

Milling

The replacement of aluminum with steel for spar and wing sections illustrates the magnitude of the milling problem that has been created. For example, in side milling wing spars, a typical side mill cut might be taken with a 6 in. carbide cutter, Table 4. In milling an aluminum spar, the feed rate would be 150 in. per min. while in milling 4340 steel, 52 R_c, the feed rate would have to be dropped to 4 in. per min. In milling the aluminum spar, the cutter would be changed after 3000 linear feet travel of the cutter. In milling the 4340 steel at 52 R_c, the cutter would have to be changed after only 30 ft of travel.

The tool life versus cutting speed characteristics in face milling of the thermal-resistant alloys are shown in Fig. 1. The feed rate and the production rate is proportional to the cutting speed and, hence,

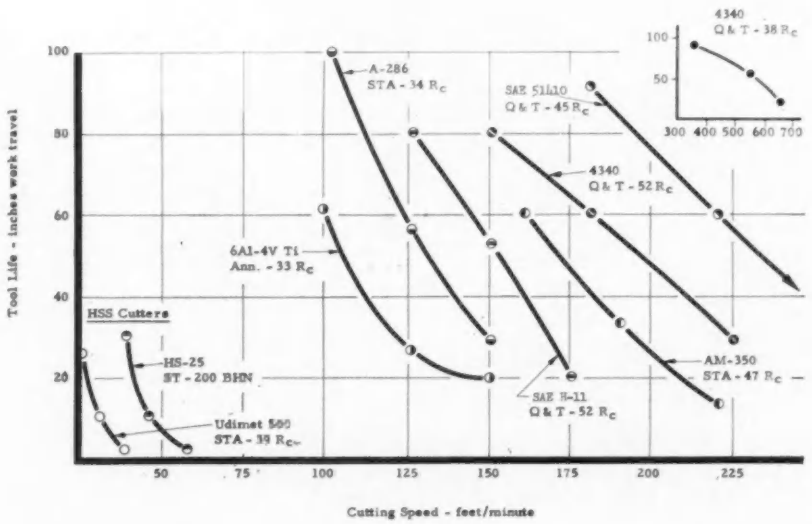

Fig. 1 — Face milling high-strength thermal-resistant alloys. Tool material: carbide; cutter: 4 in. diameter single tooth face mill; depth of cut: 0.10 in.; width of cut: 2 in.; wearland: 0.015 in.; cutting fluid: none.

getting tougher to machine

and limitations of high-strength thermal resistant alloys.

Table 1 — Aircraft and Missile Alloys

Alloy Group	Typical Alloys
1. Martensitic Low-Alloy Steels	SAE 4340, SAE 4130, 17-22-AS (14 MV), 14 CMV
2. Hot-Work Die Steels	SAE H-11, Halcomb 218, Peerless 56, Tricent, UHS 260, Unimach 2
3. Austenitic Stainless Steels	A-286, N-155, SAE 30302 19-9 DL
4. Martensitic Stainless Steels	SAE 51410, AISI 422
5. Precipitation-Hardening Stainless Steels	AM-350, 17-7 PH
6. Nickel-Base High-Temperature Alloys	Inconel 700, Inconel 901, R-235, Udimet 500
7. Cobalt-Base High-Temperature Alloy	HS-25
8. Titanium Alloy	6A1-4V-Titanium

Table 2 — Chemical Composition of Alloys Used in Tests

	Nominal Composition, %										
	C	Mn	Si	Ni	Cr	Mo	V	Co	Ti	Fe	W
SAE 4340	.40	.70	.30	1.80	.80	.25				Bal	
SAE H-11	.40	.30	.90		5.00	1.30	.45			Bal	
Tricent (300M)	.43	.80	1.60	1.80	.80	.40	.05			Bal	
SAE 51410	.15				12.3					Bal	
AM 350	.10			4.2	17.0	2.8				Bal	
A-286	.08			25.0	14.8	1.3	.30		1.9		
HS-25	.10			10.0	20.0			50.0		1.5	15.0
Udimet 500	.10			52.5	16.0	4.0		19.0	3.0	2.0	
Ti 6A1-4V	Al 6%; V 4%; Ti 90%										

Table 3 — Heat Treatment of Alloys Used in Tests

	Heat Treatment
SAE 4340, quenched and tempered 38 R_c	1475 F-1 hr, water quench temper: 1000 F-1 hr, air cool
SAE 4340, quenched and tempered 52 R_c	1475 F-1 hr, water quench temper: 450 F-1 hr, air cool
SAE H-11, quenched and tempered 52 R_c	1850 F-2 hr, air cool double temper: 1075 F-2 hr, air cool
Tricent (300M), quenched and tempered 50$_c$	1700 F-1 hr, cool to 1600 F-½ hr, air cool to 1000 F, quench in salt at 400 F, air cool double temper: 1000 F-2 hr, air cool
SAE 51410, quenched and tempered 45 R_c	1850 F-1 hr, water quench temper: 300 F-2 hr, air cool
AM 350, solution treated and aged 47 R_c	1750 F-1 hr, water quench subzero cool at 100 F-3 hr temper: 850 F-3 hr, water quench
A-286, solution treated and aged 34 R_c	solution treat at 1650 F-1 hr, water quench age at 1325 F-16 hr, air cool
HS-25, solution treated 200 Bhn	solution treat at 2250 F-1 hr, rapid air cool
Udimet 500, solution treated and aged 39 R_c	solution treat at 1975 F-4 hr, air cool age at 1550 F-24 hr, air cool age at 1400 F-16 hr, air cool
Titanium 6A1-4V, annealed 33 R_c	anneal at 1300 F-2 hr, air cool

Table 4 — Comparison-Spar Milling of Aluminum versus 4340 Steel

Side Milling: Cut 2 in. wide, 0.10 in. deep
Carbide Cutter: 6 in. diameter, 6 teeth

	Cutting Speed, fpm	Feed Rate, in. per min	Tool Life, Linear Travel of Cutting, ft
Aluminum	5000	150	3000
4340 Steel, 38 R_c	400	15	45
4340 Steel, 52 R_c	150	4	30

[1] Machining Characteristics of High-Strength Thermal-Resistant Materials — Phase II, Interim Engineering Report No. 6. Air Materiel Command, Contract No. AF 33(600)-3597.

[2] The Machining of Ultra-Strength Alloys, J. Maranchik, Jr., J. V. Gould, and P. R. Arzt. SAE Journal, May, June, July, August, 1959.

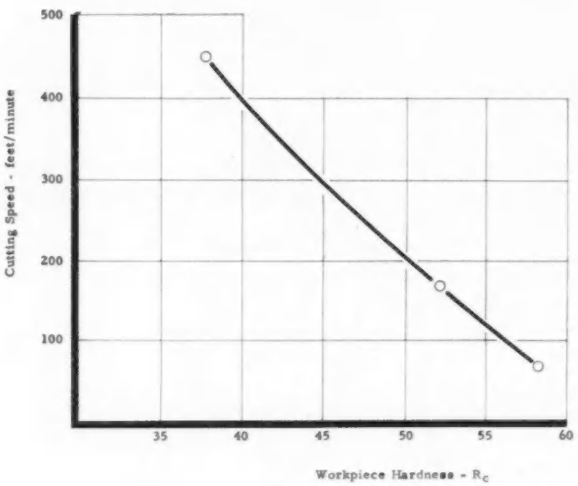

Fig. 2 — Cutting speed versus workpiece hardness for face milling SAE H-11. Cutter: 4 in. diameter face mill with carbide tipped teeth; feed per tooth: 0.005 in.; depth of cut: 0.10 in.; width of cut: 0.10 in.; width of cut: 2 in.; tool life: 50 in. per tooth (approximate).

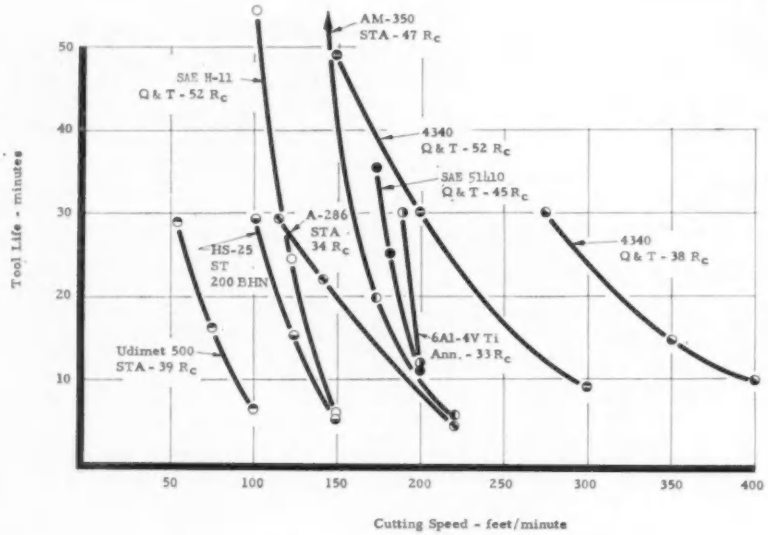

Fig. 3 — Turning high-strength thermal-resistant alloys. Tool material: carbide; depth of cut: 0.10 in.; feed: 0.009 in. per rev; wearland: 0.015 in.; cutting fluid: none.

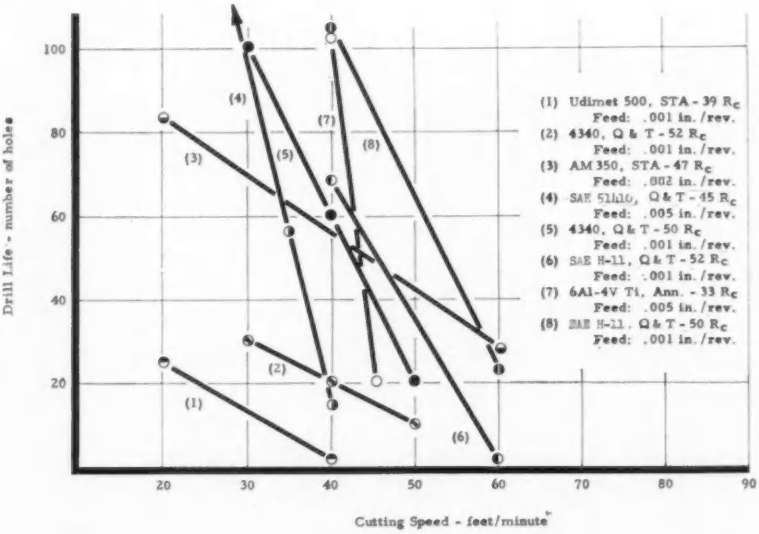

Fig. 4 — Drilling high-strength thermal-resistant alloys, high-speed steel drills. Drill material: T-15 HSS, diameter 0.25 in.; depth of hole: 0.50 in. through hole; cutting fluid: highly sulfurized oil diluted 1:1 with light machine oil.

alloys which can be machined at high speeds can be machined at high production rates. The relative cutting speed to obtain a constant cutter life of 40 in. work travel is indicated in Table 5. The HS-25 and the Udimet 500 alloys could not be face milled with carbide cutters with any appreciable cutter life.

The trend in the airframe and missile industry is to use harder and harder steels. The effect of hardness on cutting speed in carbide face milling is shown in Fig. 2. The cutting speed had to be dropped to 60 fpm to mill SAE H-11 at 58 R_c and obtain a cutter life of 50 in. per tooth.

Turning

The tool life versus cutting speed curves for carbide turning of the high-strength thermal-resistant alloys is shown in Fig. 3. The cutting speed for 30 min. tool life of the alloys is listed in Table 6. Note that the relative order of machinability in turning is not the same as in milling for some of the alloys (compare Tables 5 and 6).

Drilling

The high-speed-steel-drilling characteristics of the aircraft and missile alloys are shown in Fig. 4. The data is for a ¼ in. diameter drilled hole, ½ in. deep. The data is given for a feed which gave optimum drill life. Drilling the high-temperature alloys and the hard steels with high-speed-steel drills is very critical and requires careful selection of drill conditions to get adequate drill life. As the hardness of the steel work material increases to the 52-54 R_c level, the drill life drops off to virtually zero (Fig. 5). (The same critical relationship of tool life to work hardness holds in end milling 4340 steel in the vicinity of 50–54 R_c.)

The type of high-speed steel is a vital factor in drilling hard steel (Fig. 6). The high-cobalt high-

Table 5 — Relative Face Milling Properties of Alloys
(Data Taken from Fig. 2)

	Cutter Material	Cutting Speed for 40 in. Linear Cutter Travel
4340 Q & T[1]-38 R_c	Carbide	600
51410 Q & T-45 R_c	Carbide	250
4340 Q & T-52 R_c	Carbide	210
AM-350 STA[2]-47 R_c	Carbide	185
H-11 Q & T-52 R_c	Carbide	170
A-286 STA-34 R_c	Carbide	140
Ti-6A1-4V-33 R_c	Carbide	115
HS-25 Sol.[3]-200 Bhn	High-Speed Steel	40
U-500 STA-39 R_c	High-Speed Steel	25

[1] Q & T — Quenched and Tempered.
[2] STA — Solution Treated and Aged.
[3] Sol. — Solution Treated.

Table 6 — Relative Turning Properties of Alloys
(Data Taken from Fig. 3)

	Cutting Speed for 30 min Tool Life
4340 Q & T-38 R_c	275
4340 Q & T-52 R_c	200
Ti-6A1-4V-33 R_c	190
51410 Q & T-45 R_c	180
AM-350 STA-47 R_c	160
H-11 Q & T-52 R_c	120
A-286 STA-34 R_c	115
HS-25 Sol.-200 Bhn	100
U-500 Sta-38 R_c	55

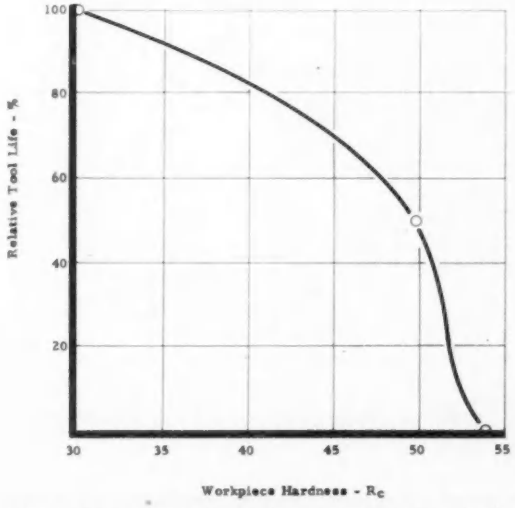

Fig. 5 — Effect of workpiece hardness on tool life for end milling and drilling SAE 4340 with high-speed-steel end mills and drills.

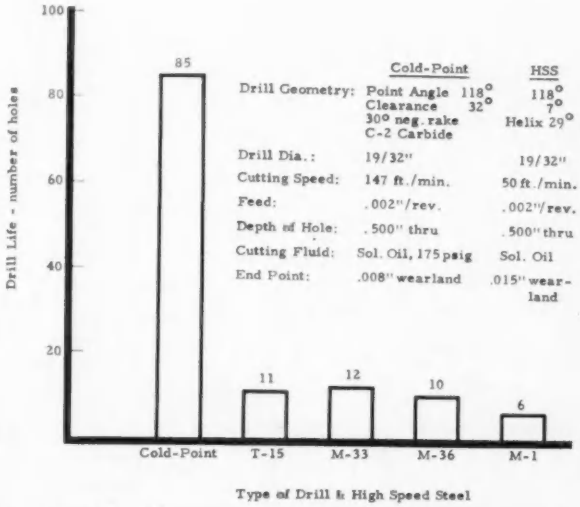

Fig. 6 — Drilling Tricent quenched and tempered to 50 R_c using cold-point and high-speed-steel drills — effect at different cutting speeds.

Aircraft and missile alloys

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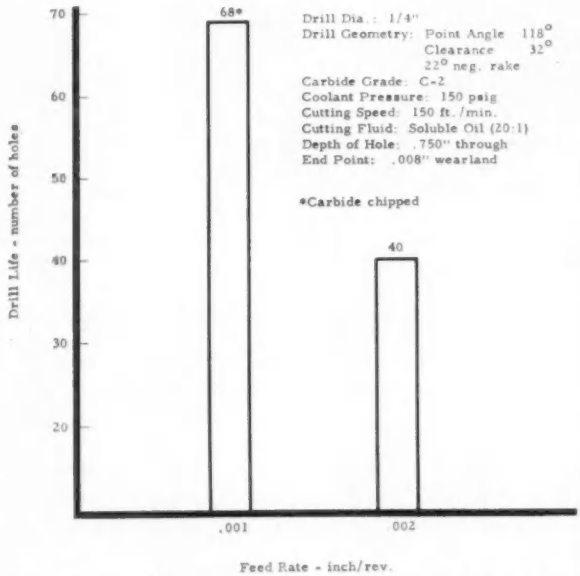

Fig. 7 — Drilling Tricent quenched and tempered to 55–57 R_c using cold-point drills — effect of feed.

speed steel drills, such as T-15, M-33, and M-36 gave considerably greater drill life than the M-1 high-speed steels.

A significant improvement in drill life and penetration rates on the hard steels can be obtained by using the carbide-tipped cold-point drills. In this drill a cutting fluid, under pressure, is pumped through the drill body and emerges at the drill lips. The fluid serves the purpose of cooling the drill and also washes the chips away. In drilling M-300 steel (Tricent) at 50 R_c the use of a cold-point drill increased drill life over eight times (Fig. 6).

The cold-point drill has also been used to drill M-300 steel at 55–57 R_c hardness. The cold-point drill requires a low feed. Thus, in drilling the 55–57 R_c steel, Fig. 7, the drill life increased from 40 holes at 0.002 in. per rev, to 68 holes at 0.001 in. per rev.

Tapping

The high-speed-steel tapping characteristics for the alloys are shown in Fig. 8. The data are given for the optimum tap type. Thus, on A-286 a 2-flute spiral-point tap was used, while titanium tapped best with a 3-flute spiral-point tap. The percent of thread has a strong influence on tap life, Fig. 9. The tap life can be increased about 10 times by changing from a 75% to a 60% thread.

Grinding

In grinding the alloys, there are two factors that require consideration. First, it is desirable to have a high *G* ratio, which is the ratio of volume of metal removed to volume of wheel wear. Second, it is important that the alloys be ground with a minimum of distortion.

The *G* ratio is affected mainly by wheel speed and grinding fluid. In general, the higher wheel speeds result in higher *G* ratios (Fig. 10). The grinding fluid has an even greater influence on *G* ratio (Figs. 11–16). The highly sulfurizied oil greatly increases the *G* ratio in grinding these alloys. On each alloy the grinding wheel grade was selected to give optimum wheel life.

Most aircraft and missile components are de-

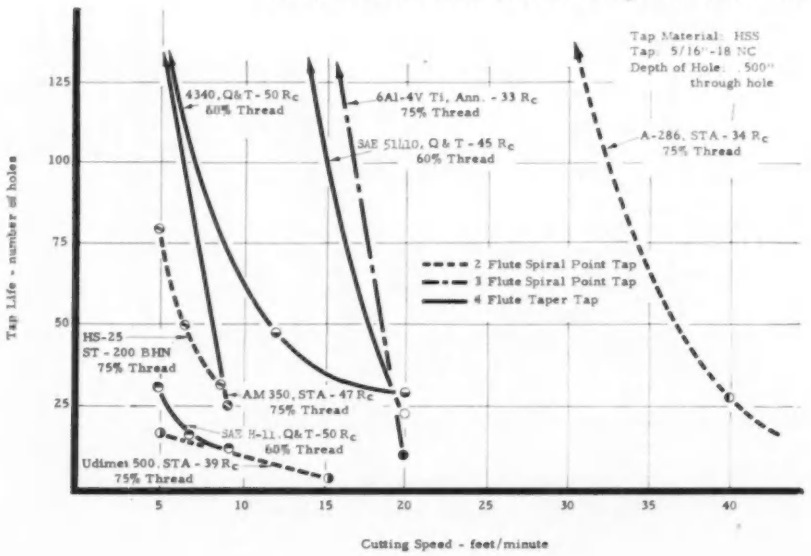

Fig. 8 — Tapping high-strength thermal-resistant alloys — high-speed steel taps.

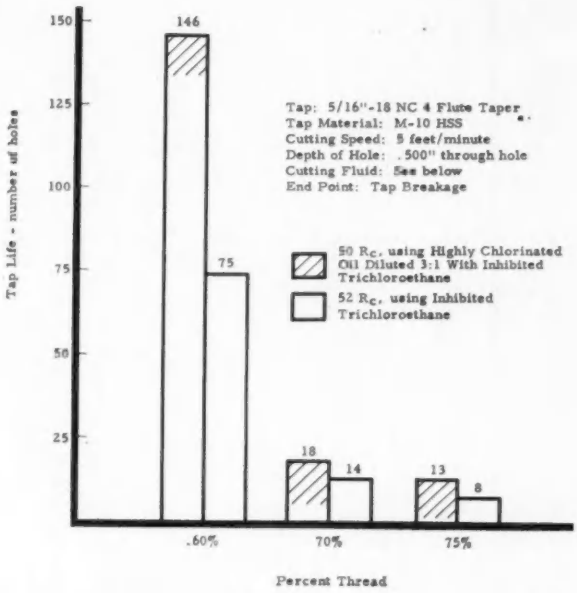

Fig. 9 — Tapping 4340 steel quenched and tempered to 50–52 R_c — effect of percent thread.

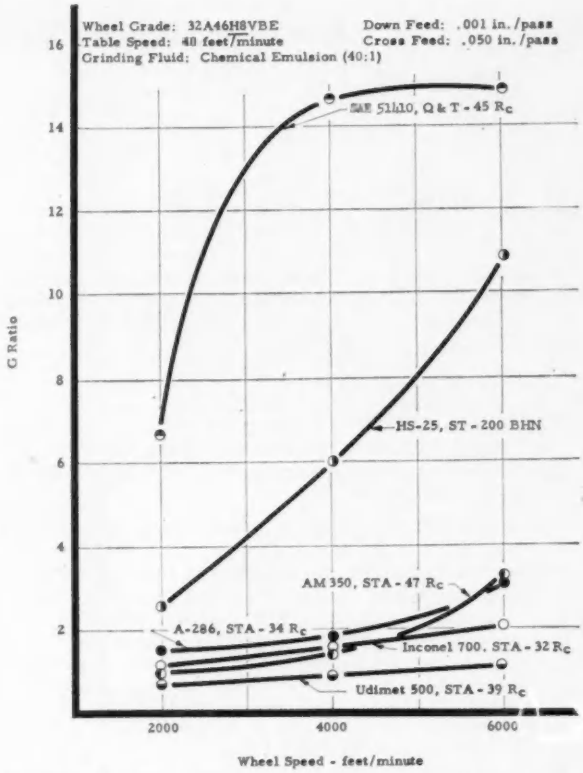

Fig. 10 — Surface grinding thermal-resistant alloys — G ratio versus wheel speed.

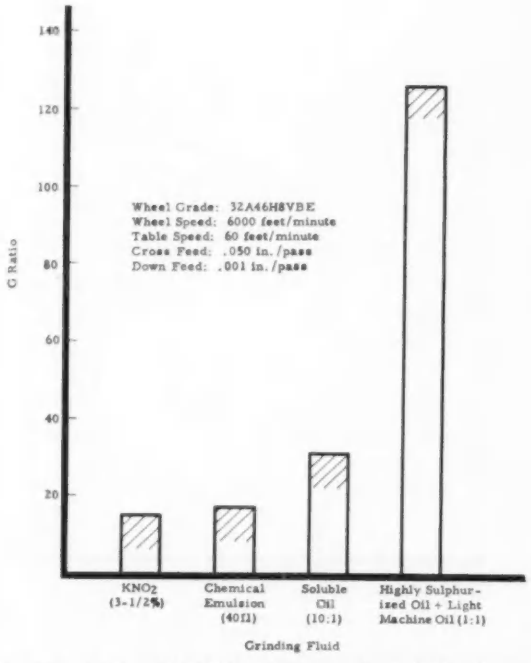

Fig 11 — Grinding SAE 51410 stainless steel quenched and tempered to 45 R_c — G ratio versus grinding fluid.

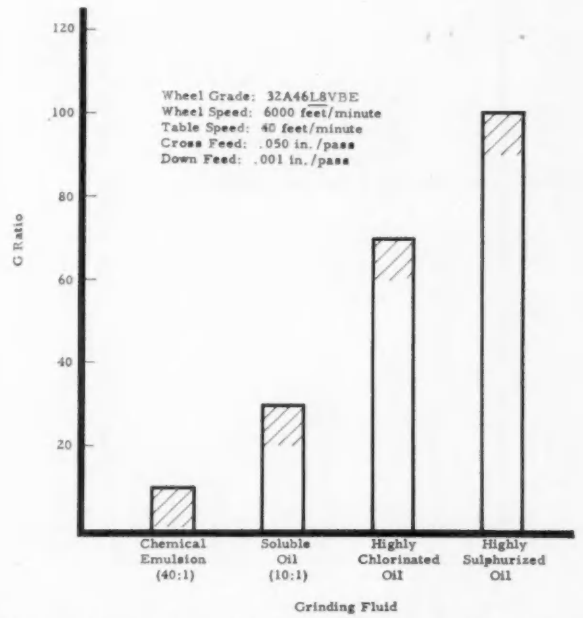

Fig. 12 — Grinding HS-25 solution-treated to 200 Bhn — G ratio versus grinding fluid.

Aircraft and missile alloys

. . . continued

signed with thin sections for weight reduction. In grinding these sections it is imperative that the distortion be minimized. The distortion is caused by introduction of residual stress during the grinding process. To minimize this residual stress and, hence, the distortion, the following grinding conditions should be employed:

1. Soft grinding wheel
2. Low grinding wheel speed
3. Highly sulfurized grinding oil
4. Light downfeed during the last 0.010 in. of stock removal (such as the Low Stress Down Feeds shown in Fig. 18.

The importance of wheel grade, wheel speed, and grinding fluid is shown in Fig. 17. The distortion in grinding a test strip of 4340 steel is seen to increase as the wheel speed increases and as the wheel hardness increases. (N is a hard grade, while H is a soft grade wheel.) This marked effect of down feed on distortion is shown in Fig. 18. The minimum distortion is obtained by using the light down feed described as a Low Stress Down Feed.

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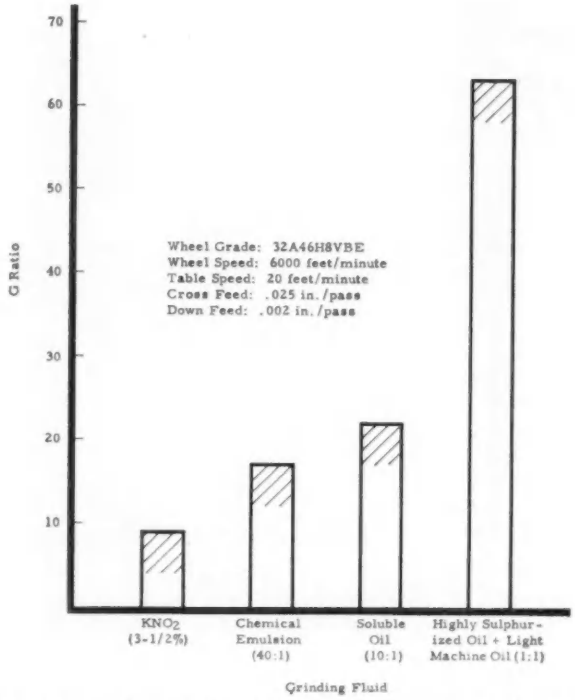


Fig. 13 — Grinding AM 350 solution-treated and aged to 47 R_c — G ratio versus grinding fluid.

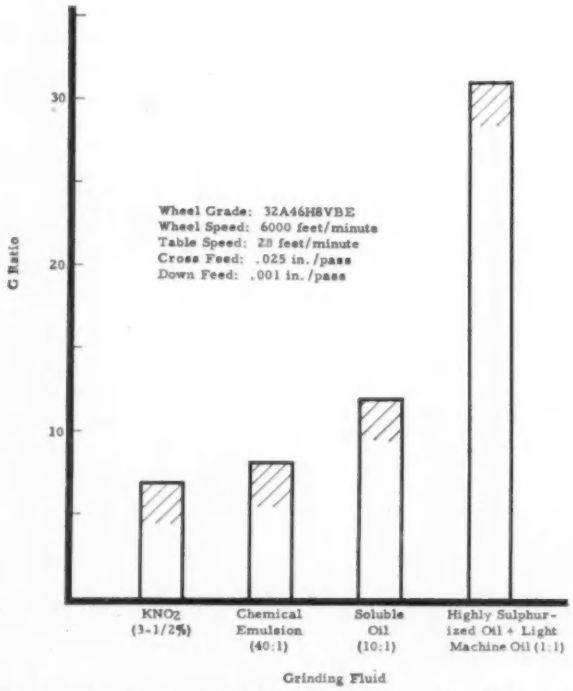


Fig. 14 — Grinding A-286 solution-treated and aged to 34 R_c — G ratio versus grinding fluid.

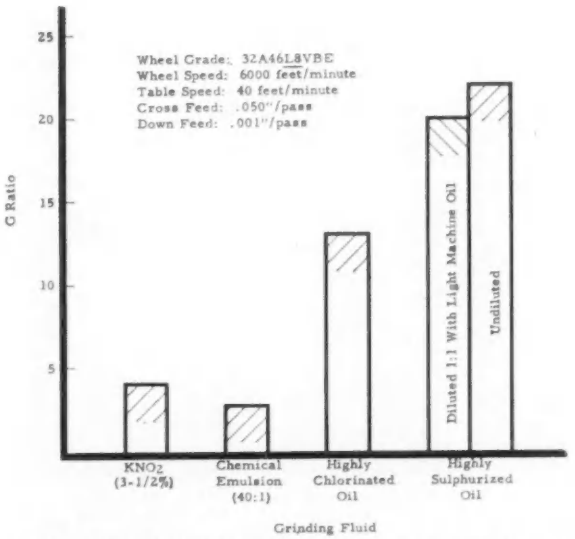


Fig. 15 — Grinding Udimet 500 solution-treated and aged to 39 R_c — G ratio versus grinding fluid.

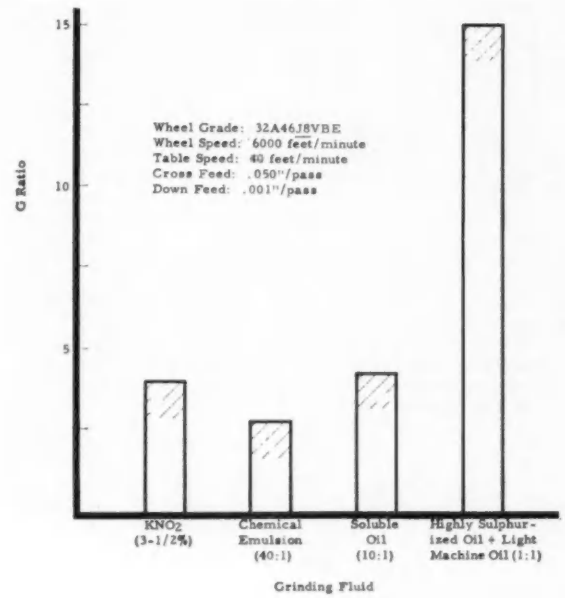
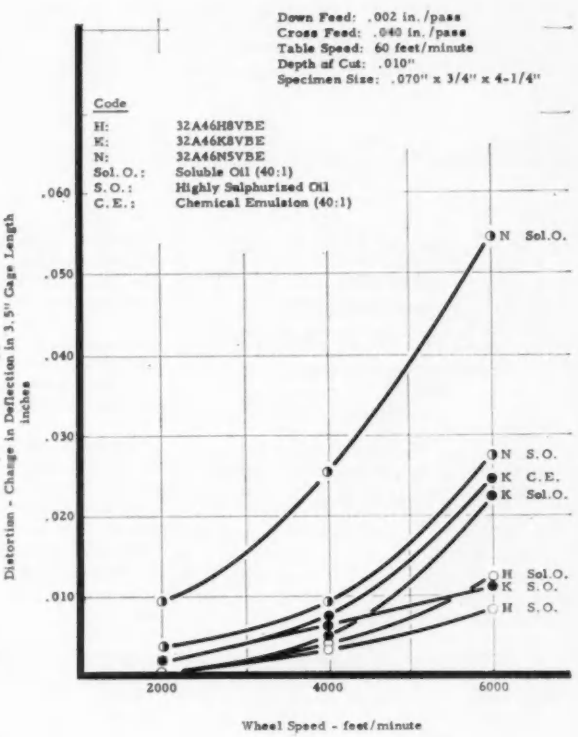


Fig. 16 — Grinding Inconel 700 solution-treated and aged to 31 R_c — G ratio versus grinding fluid.

Fig. 17 — Change in deflection versus wheel speed for surface grinding 4340 steel quenched and tempered to 52 R_c — effect of wheel grade and grinding fluid.



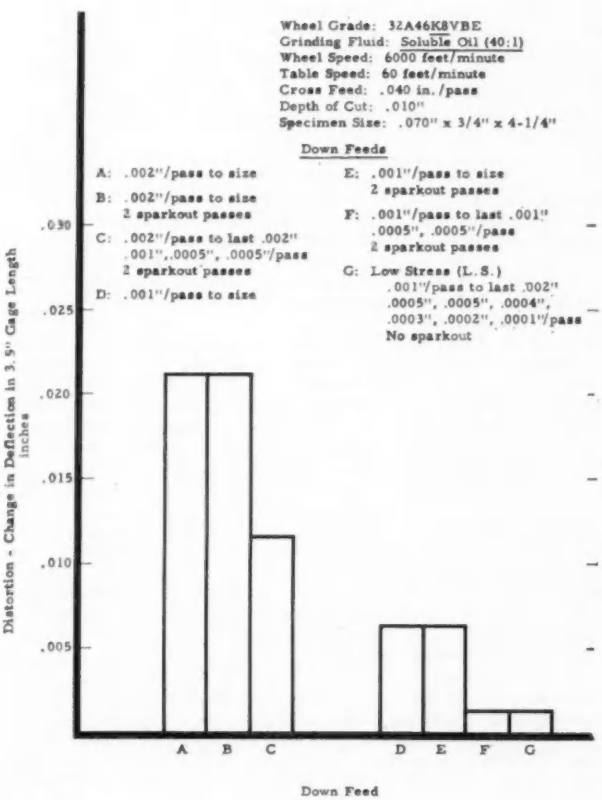

Wheel Grade: 32A46K8VBE
Grinding Fluid: Soluble Oil (40:1)
Wheel Speed: 6000 feet/minute
Table Speed: 60 feet/minute
Cross Feed: .040 in./pass
Depth of Cut: .010"
Specimen Size: .070" x 3/4" x 4-1/4"
Down Feeds
A: .002"/pass to size
B: .002"/pass to size 2 sparkout passes
C: .002"/pass to last .002" .001", .0005", .0005"/pass 2 sparkout passes
D: .001"/pass to size
E: .001"/pass to size 2 sparkout passes
F: .001"/pass to last .001" .0005", .0005"/pass 2 sparkout passes
G: Low Stress (L.S.) .001"/pass to last .002" .0005", .0005", .0004", .0003", .0002", .0001"/pass No sparkout
Distortion - Change in Deflection in 3.5" Cage Length inches
.030
.025
.020
.015
.010
.005
A B C D E F G
Down Feed

Fig. 18 — Change in deflection versus down feed for surface grinding 4340 steel quenched and tempered to 52 R_c.

Little Deterioration Found in Scaled-Up Fuel Storage Program

THE Navy-CRC barge storage program to . . .

• Determine the scale-up factor in going from bottle or drum storage to storage in bulk (as in tanks or vessels)

• Obtain correlation between actual storage results and the predicted stability, using a number of available predictive tests . . . has revealed the following which is reported in CRC 341, "Navy-CRC Barge Storage Program."

(1) Scale-up in sample size appears to have little effect upon the degree of deterioration in storage. (The low values for insoluble gum in the fuels stored in barge tanks are believed to have resulted from difficulties in obtaining representative samples rather than the fuels having appreciable lower contents of insoluble gum.)

(2) Correlation is evidenced between mildly accelerated storage (110 F) and ambient temperature storage tests.

(3) No correlation was found between the observed and predicted stabilities with any of the predictive techniques tested. This was shown with the nonadditive fuels and with the additive blends.

(4) Reproducibility of tests in use for either appraising the stability of fuels, or estimating the degree of deterioration, is poor.

Seven fuels were used in the bulk storage program to make six blends of straight-run and catalytically cracked, two straight-run fuels, and four blends containing additives. Fourteen laboratories participated in the program of testing the fuels, and each laboratory determined the soluble gum, insoluble gum, and percent light transmission on the interim samples and on the final samples. Comparison of the values for these three tests showed quite poor reproducibility between the participating laboratories. This was apparent at each sampling, and particularly at the 18-month period.

To assist in evaluating this point, each of the laboratories was requested to make five separate determinations on two of the fuels at the end of the 24-month period to permit a statistical appraisal of the repeatability and reproducibility of soluble gum, insoluble gum, and percent light transmission.

CRC Report 341 contains 67 pages including tables and charts.

To Order CRC Report 341 . . .
from which material for this article was drawn, see p. 6.

Briefs of SAE PAPERS

continued from p. 6

man heat transfer in automobile are conditioned air temperature, velocity, volume, humidity and distribution; design factors that influence heating, ventilating and air conditioning such as use of light color or reflective type paint, tinted and/or shaded glass, breathable type seat covers, etc.

Progress of Automotive Heating Through Years, H. V. JOYCE. Paper No. 146B. Review of car heaters and comfort devices used; reference made to heater, installed on 1933 Ford V-8, and fresh air hot water heater for 1949 Ford line; 30,000 Btu Stewart-Warner gasoline burning type fresh air heater on 1956 Chrysler line; factors to consider in engineering of heating system; air distribution, temperature control, air blending system, defrosting, controls and quick warm up devices; three approaches to heating and defrosting as illustrated by 1960 models of Valiant, Corvair, and Falcon.

Controlling Automotive Air Conditioner for Comfort, J. T. KREASKY. Paper No. 146C. Functions of vapor compression type automotive air conditioner using R-12 refrigerant and components; determining discharge air temperature required; evaporator temperature control and control devices; method used by Chrysler Corp., known as reheat system which involves adding heat to evaporator discharge air by means of liquid-to-air heat exchanger downstream of evaporator, using engine coolant as heat source; comparisons between reheat and evaporator temperature control systems.

Early Wind Tunnel Testing at Ford, A. H. ESPER. Paper No. 148A. Description of first model tunnel, built in 1929 to develop Ford Tri-Motor Airplane; use of tunnel for testing car models and for aircraft work; examples and illustrations of streamlining concept as applied to automobile body design.

Several Possible Paths to Improved Part-Load Economy of Spark-Ignition Engines, A. E. CLEVELAND, I. N. BISHOP. Paper No. 150A. It is shown that due to many losses in conversion of heat mechanical energy gallon of fuel provides less than ¼ of its mechanical equivalent of useable energy at flywheel; losses are described and their magnitude at one speed and road load corresponding to speed and road load of compact car operating at 40 mi per hr appraised; areas where improvements in efficiency may be obtained indicated.

New Tool for Combustion Research — Quartz Piston Engine, F. W. BOWDITCH. Paper No. 150B. Design features of single-cyl, overhead valve engine equipped with quartz topped piston, used by General Motors Research Laboratories, Warren Mich.; engine permits unobstructed view of processes occurring in combustion chambers of compression ratios up to 10.7:1; high speed photographs illustrating some of normal and abnormal combustion studies possible.

Automatic Highway and Driver Aid Developments, H. M. MORRISON, A. F. WELCH, E. A. HANYSZ. Paper No. 151A. Details of operation of highway model, built by Research Laboratories, General Motors Corp. which comprises Auto-Control, applicable to limited access highways and embodied in 1/40 scale model; Electro Lane is path error detector and Hy-Com is l-f induction radio communications system; each of latter provides aid to drivers and with further development might be applicable for use in future; details of functions and operation of each system.

Development of Smiths Automatic Transmission for Rootes Group Range of Light Cars, C. S. STEADMAN. Paper No. 152A. Eaton Manufacturing Co., Cleveland, Ohio, developed magnetic powder coupling considered by Smiths Motor Accessories Ltd., to possess characteristics possibly adaptable to European sized passenger cars; basic principles of magnetic powder coupling; development of basic design and fully automatic transmission; laboratory test facilities; road testing and proving of production version; control system components and circuit.

Engineering Highlights of 25 Compact Cars, J. R. BOND. Paper No. 152B. Compact car considered as one with wheelbase between 100 and 110 in.; data for compact cars are presented with idea of noting areas of

Progress on B-70 Hydraulic System Design & Hardware

Based on talk by

BENJAMIN G. PETERSON
North American Aviation, Inc.

(Presented before SAE Rockford-Beloit Section)

THE weapon system concept has been successfully demonstrated in the B-70 program. There are some measureable development and hardware accomplishments realized to date.

For example, the hydraulic system provides power for the air vehicle at a pressure of 4000 psi with a maximum fluid temperature of 450 F . . . a 30% increase in pressure and 20% increase in fluid temperature over the design characteristics of the B-58.

Hydraulic components are receiving considerable attention. It was necessary to develop metallic seals in lieu of elastomer seals in order to withstand the increase in pressure (3000 to 4000 psi) and also the increase in operating temperature (265 to 450 F).

Leakage and friction are the major problems. Sufficient metal-to-metal contact must be attained in order to prevent leakage and yet be friction-free to the extent that it will not have an adverse effect on operation. Successful material compatibility tests have been conducted; however, sufficient repeatability hasn't been attained to fully substantiate air-worthy components.

In hydraulic valve and cylinder fabrication, operation involved metal-to-metal contact where the life of the assembly was limited to a mere 10 cycles. Research led to a molybdenum spray bond coating where operation was extended to 50,000 cycles while undergoing side loads typical of hydraulic cylinder and valve applications of flight control mechanizations.

Case Hardenability Of SAE Steels Reported

Based on paper by

J. A. HALGREN and E. A. SOLECKI
International Harvester Co.

THE case hardenabilities of SAE 4028H, 8620H, 4620H, and 4815H steels appear to be related directly to the core hardenabilities of these grades, adjusted to a common carbon level. And the case hardenability rating of these grades in ascending order is 4000, 4600, 8600, and 4800.

These facts were developed through investigation of end quench case hardenability, sponsored by Division 33 — Gear Metallurgy — of the SAE Iron and Steel Technical Committee.

The hardenability was determined at

continued on next page

agreement or diversified opinion; included are representative compact versions from each major importing country, French Peugeot, Italian Fiat, British Jaguar and German Mercedes; all cars discussed have 6-cyl engines, with exception of 4-cyl Peugeot; analysis refers to package, frames, suspensions, steering, engines and transmission.

New Techniques for Full Scale Testing, J. F. WHITE. Part of SP-180. Ford Motor Wind Tunnel designed to perform internal aerodynamic tests in controlled atmosphere and also appropriate for external aerodynamics; general arrangement of tunnel and most important features; use of portable aerodynamic force measuring scales of novel design which permit use of tunnel for full scale aerodynamic testing of passenger cars; preliminary tests, and some of applications of full scale testing.

Automobile Aerodynamics, K. B. KELLY, P. KYROPOULOS, W. F. TANNER. Part of SP-180. Progress report by General Motors Corp. on wind tunnel model testing; general objectives of model studies of automobile aerodynamics, general similarity laws and validity of aerodynamic model; model parameters are examined and limits established (model mounting, internal flow, full scale correlation, pressure distribution); model testing technique used; interpretation of data.

MATERIALS

Structural Adhesives in Automobiles, A. F. THOMSON, A. F. MARTIN. Paper No. 145A. Emphasis is on two polymers, namely, epoxy systems and nitrile-phenolic combinations; load and corresponding elongation readings were taken from linear portion of stress-strain curve and calculations made for secant modulus according to given formula; tensile shear strengths of typical adhesive bonds over wide temperature range are shown; details of tensile shear or overlap shear test; bend strength test, vibrational fatigue test, beam shear, and peel tests; sequence of operations most effective in obtaining maximum performance.

Decorative Plated Coatings of Improved Durability, D. M. BIGGE. Paper No. 147A. Semi-bright nickel process is employed since Oct. 1945 for plating of automobile bumpers, replacing Watts nickel process because first has better leveling properties and is easier to buff; possibility of reducing labor costs by depositing bright nickel over semi-bright nickel layer is investigated; 1 yr's atmospheric exposure at Miami, Fla., Detroit, Mich., and Pittsburgh, Pa., showed that use of buffed Watts nickel or semi-bright plus bright nickel gave superior performance.

Case Hardenability of SAE 4028, 8620, 4620 and 4815 Steels, J. A. HALGREN, E. A. SOLECKI. Paper No. 149A. End quench case hardenability investigations sponsored by Div. Gear Metallurgy of ISTC of SAE, cover high and low chemistry heats of these steels; hardenability is determined at carbon levels of 1.10% to 0.30% at 0.10% increments with Rockwell A. Superficial Rockwell 15N and Vickers 10 kg hardness procedures; results in form of iso-hardness diagrams show relationship between carbon content, hardness and position on end quench bar.

Practical Application of High Temperature Gas Carburizing, O. E. CULLEN. Paper No. 149B. Consideration of high temperature process carried out at 1800 F; rates of carburizing and carbon control methods; use of dew point or water vapor content in atmosphere gas as determining factor for maintaining furnace atmosphere carbon potentials; application of heat treat specification which called for carburizing SAE-1022 steel gears at 1850 F; program, carried out at Midland-Ross Corp., Toledo Ohio, shows that operating temperature of about 1800 F results in optimum efficiency.

MISCELLANEOUS

Engineering for Reliability, C. V. CROCKETT. Paper No. S-245. Covers such topics as: determine product needs, first cost plus maintenance must be minimum, simplicity, realistic specs, reduced maintenance requirements, make foolproof, design for easy manufacturing, testing correct deficiencies quickly and once and for all, quality control, organize for reliability.

These digests are provided by ENGINEERING INDEX, which each year abstracts 30,000 engineering articles from 1500 different publications and classifies them into 249 "fields of engineering interest."

To order the SAE papers digested here, circle the numbers in the "Readers Information Service" blank on p. 6 corresponding to the numbers appearing after the titles of the digests of the papers you want.

carbon levels of 1.10–0.30% at 0.10% increments with Rockwell A, Superficial Rockwell 15N, and Vickers 10-kg hardness procedures, and the results are presented in the form of isohardness diagrams showing the relationship between carbon content, hardness, and position on the end quench bar.

As the case hardenability rating increases, the variation in case hardenability of steels from their minimum to their maximum chemistry range appears to decrease. Reheat and quench practice tends to lower the case hardenabilities of all grades of steel slightly. The SAE 8600 grade, which contains chromium, is affected most, particularly in the hypereutectoid region. The relative case hardenability rating of the four grades of steel is not appreciably changed by reheat and quench.

According to the investigators, the end quench bar is recommended for case hardenability studies, and Rockwell 15N or Vickers 10-kg procedures should be used for measuring hardness. Since the isohardness diagrams in this paper are derived from Rockwell A procedures, and are affected by the errors introduced by their use on surfaces with hardness gradients, the present end quench bars should be rechecked by Rockwell 15N or Vickers 10-kg procedures and new isohardness diagrams should be presented in a subsequent paper.

To Order Paper No. 149A . . . from which material for this article was drawn, see p. 6.

Steel Cord Tires Cool and Comfortable

Based on paper by

M. P. BAUMONT
Manufacture Francaise des Pneumatiques, Michelin

INCREASED load carrying capacity, cool running at high speeds, longer tread life, better road holding, and increased comfort are advantages gained from the steel-cord, single-ply casing construction used in the Michelin "X" tire.

The wall plies are made with an archwise arrangement of the steel cords, that is, they are laid on the shortest path at right angles from base to bead. The cords can work in the most rational fashion possible and when the casing is distorted under load there is hardly any distortion transmitted to the tread as there is with the conventional tire.

The single-ply construction eliminates the shear forces between plies which exist in all multiply tires. Consequently, there is much less internal heating and less loss of power through tire drag or tractive resistance. Such heat as is generated is easily dispersed through the thin, but strong walls aided by the thermal conductivity of the steel casing cords.

Actual measurements of vibratory energy transmitted in the vertical plane by various types of tires reflect the increased comfort obtainable from the "X" construction. At the left of Fig. 1 are measurements from a laden vehicle, at the right from an unladen one. The test covered a 2-mile run at 30 mph and the effect of road springs was eliminated so that the suspension effect of the tires alone was measured. Because "X" tires run cool, there is very little rise in pressure during running.

To order Paper No. 200A . . . from which material for this paper was drawn, see p. 6.

Proposes Simplified Oil Changing Practice

Based on talk by

C. C. MOORE, Union Oil Co. of California

(Presented before SAE Southern California Section)

IN the summertime, drain oil every 2000 miles or every 60 days, whichever comes first. In the wintertime, drain every 2000 miles or every 30 days, whichever comes first. This is the recommendation proposed to passenger car manufacturers by the Lubrication Committee of the American Petroleum Institute. If adopted it would provide Mr. Motorist with excellent protection

continued on page 126

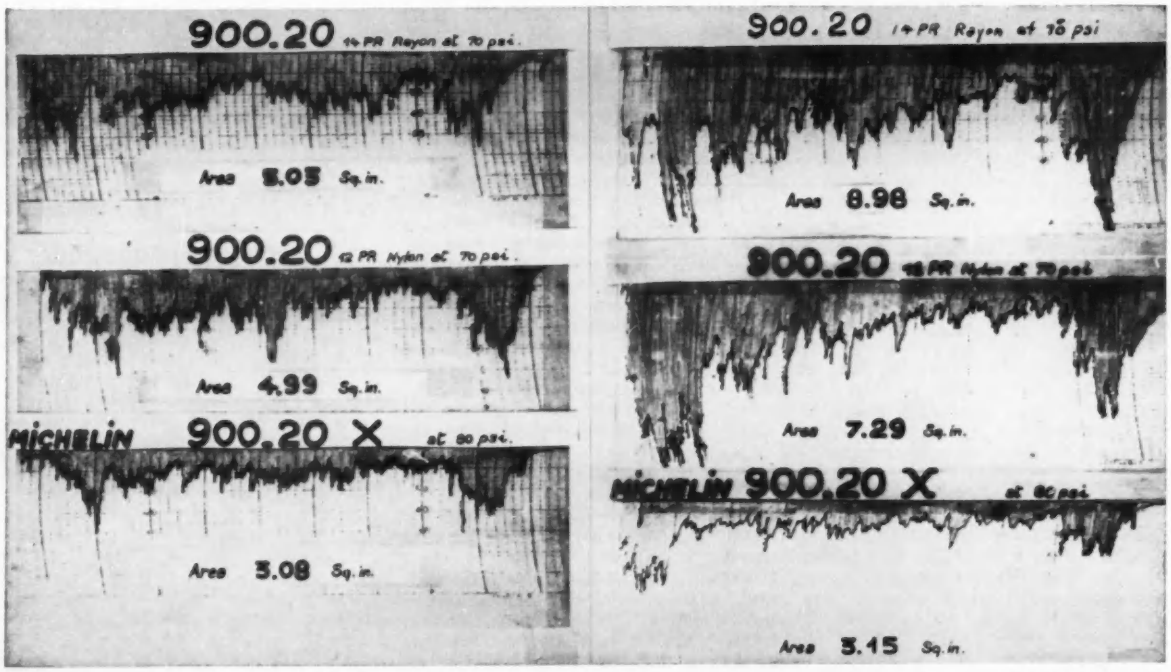

900.20 14 PR Rayon at 70 psi.
Area 5.05 Sq. in.
900.20 12 PR Nylon at 70 psi.
Area 4.99 Sq. in.
MICHELIN 900.20 X at 60 psi.
Area 3.08 Sq. in.
900.20 14 PR Rayon at 70 psi
Area 8.98 Sq. in.
900.20 12 PR Nylon at 70 psi.
Area 7.29 Sq. in.
MICHELIN 900.20 X at 60 psi.
Area 3.15 Sq. in.

Fig. 1 — Chart at left shows vibratory energy transmitted in vertical plane by three types of tires on a laden vehicle. Contrast this with measurements on right-hand chart taken on same vehicle unladen, with tire pressures left at laden pressure values. Returning-empty bounce is negligible with "X" tire.

SAE NEWS

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A report from the BOARD OF DIRECTORS

At the April 8, 1960, meeting of the Board of Directors, the following actions were taken:

APPROVED

INCREASE in membership dues **(Summary 1)**

PERMISSIVE supplemental allocation of funds to Sections and Groups **(Summary 2)**

Establishment of a new **STUDENT BRANCH** at Manhattan College **(Summary 3)**

Elimination of member **REGISTRATION FEE** at Summer Meeting and reduction of nonmember registration fee **(Summary 4)**

Delegation of administration of **SAE SPEAKER EXPENSE** policy to Engineering Activity Board **(Summary 5)**

Appointment of **E. J. MANGANIELLO** to Guggenheim Medal Board **(Summary 6)**

Election to **SAE MEMBERSHIP** for 121 applicants **(Summary 6)**

An amendment to the Guideposts of the Membership Grading Committee **(Summary 6)**

REJECTED

16 applicants for **MEMBERSHIP** **(Summary 6)**

Summary (1)

SAE Member Dues Increased

The Directors approved an increase in membership dues that will become effective October 1, 1960. This upward modification of the dues schedule, which stems from a Finance Committee recommendation made last September, will mean a dues raise of 20% for most members.

The new dues schedule is shown on the opposite page, page 99, in the article by President Chesebrough.

In the lengthy and detailed discussion which preceded this action at the meeting, the Directors reviewed and re-evaluated the Society's financial problems. They again looked at other possible means of producing additional income or reducing costs.

In the discussion, President Chesebrough read a proposed statement of Philosophy of SAE Financial Management, upon which the Finance Committee had predicated its dues proposal. He offered this statement to the Directors as a yardstick for reviewing and acting on the dues increase proposal. This Philosophy of SAE Financial Management, which the Directors adopted, is as follows:

1. Dues should be limited to those costs which are essential to maintain the basic services of the Society as defined in the Constitution.
2. Special services which are valuable to only a limited number of members should be on a self-sustaining basis.
3. The Society should be reimbursed in full by industry contributions for the technical services it renders through its technical committees.
4. By-products of the Society's activities which have commercial value, such as displays and advertising, should be sold to industry and the funds used in areas which serve the greatest number of members.
5. A reasonable contingency fund should be provided in the annual budget to guard against deficits.
6. An adequate reserve should be established.
7. Investment income should be reinvested.

Acceptance of this philosophy, plus an analysis of recent, current, and projected future SAE financial data led the Directors to agree to the inevitability of a dues increase. They weighed carefully the possible negative effects of such an increase against the potential plus values. Full consideration was given to the economic hardships in certain industrial areas from which SAE members come, the competitive problem of other engineering societies, and the effect of a dues increase on membership growth.

Before agreeing on the modified dues schedule shown on the opposite page, the Directors gave serious thought to three different schedules. The one finally adopted is substantially the one recommended by the joint committee of the Membership Committee Executive Committee and the Sections Committee Executive Committee. The adopted plan sets up an added incentive for SAE Enrolled Students to apply for SAE membership upon graduation by reducing their dues from $10 to $6 in their first year out of school. It also retains the dues reduction to $10 for members over 65, but reduces their qualification for the $10 rate from 25 to 20 years of paid membership. Under the plan adopted, the dues increase for all other members will be 20%.

Summary (2)

Lift to Sections Finances

Governing Boards of Sections and Groups will be granted a supplemental allocation of up to $150 per year, when proper need is demonstrated. This is, of course, in addition to the $4 per member within its territory granted to each Section or Group.

Responsibility for administering requests for these supplemental allocations was given to the Sections Board. This action permits Governing Boards of Sections, which have curtailed services to members and Enrolled Students because of financial strain, to seek needed amounts up to $150 for approved activities. In the past, special appropriations largely have been requested and granted to meet emergency situations.

The Directors took this action at the behest of the Sections Board and in recognition of the increased costs faced by Sections and Groups in rendering their services to members.

Summary (3)

New Student Branch

A Student Branch Charter was granted to the SAE student organization at Manhattan College in New York City. Support for this move had been received from the College and members of the SAE Metropolitan Section. Endorsement of this action also came from the Sections Board and its Student Committee.

Summary (4)

Summer Meeting Registration Fee Reduced

The $7.50 registration fee which members formerly paid at the SAE Summer Meeting will be eliminated,

beginning with the 1960 Summer Meeting in Chicago. In addition, the nonmember registration fee for the Summer Meeting will be reduced from $15 to $7.50.

The Directors took this action in view of the change in character of the Summer Meeting . . . with greater emphasis on technical papers and sessions to meet growing member demands and a de-emphasis of nontechnical features. In the future, all nontechnical events will be set up on a self-supporting basis.

Growing out of this action was another to apply the entire $7.50 nonmember registration fee at Summer Meeting toward an applicant's initiation fee—if the membership application is received within three months from the Meeting. In the past, only $5 of the $15 nonmember registration fee could be applied.

Summary (5)

Policy Reaffirmed on Payment of Speakers' Travel Expense

The Engineering Activity Board has been delegated the responsibility of administering the Society's policy on reimbursing authors who present papers at SAE meetings. This policy, an existing one which was reaffirmed by the Directors, is as follows:

1. Requests must be made by the Activity Committee or Program Planning Committee concerned, before any commitment is made with the proposed participant.
2. Requests for travel expense must be submitted at least 90 days before the meeting involved to the Engineering Activity Board for approval.
3. Each request must show that the proposed participant is indispensable to the meeting program and that he is unable to arrange for payment of travel expense from any other source.

Society Modifies Dues Schedule

by SAE President **Harry E. Chesebrough**

Harry E. Chesebrough

As the members had been advised in previous communications and articles published in SAE Journal, the Board of Directors has been considering a report of the Finance Committee since last September. The Finance Committee's report stated that the economic facts of life have caught up with the Society. This report, summarized by 1959 President Raymond in the February Journal, revealed that to keep SAE finances on a sound and logical basis, and to cope with the rising cost of doing business, a dues increase is necessary.

The Directors at their April meeting thoroughly reviewed and aired the Finance Committee's report, reactions from SAE members to the proposed dues increase, and a proposal from a joint committee of the Membership Committee Executive Committee and the Sections Committee Executive Committee. The facts developed from this thoughtful and thorough analysis permitted no other conclusion than to raise the dues. This is the action taken by the Board of Directors at its meeting in April.

The new dues schedule, which will be reflected in the next dues billing to the membership and for new members elected as of October 1, is as follows:

New SAE Dues Schedule

(As compared with existing schedule)

	Old	New[1]
Former SAE Enrolled Student, for first year following graduation, regardless of age	$10	$ 6
25 years of age and under	$10	$12
26 years of age through 30	$15	$18
31 years of age through 36	$20	$24
37 years of age and over	$25	$30
65 years of age and over with 20[2] years of paid membership	$10	$10

[1] Effective Oct. 1, 1960.

[2] Under the old dues schedule, those 65 years of age and older had to have at least 25 years of paid membership to qualify for the $10 dues.

There is to be no increase in initiation fees or reinstatement fees.

Summary (6)

Other Board of Directors' Actions

E. J. Manganiello, Associate Director, National Aeronautics and Space Administration, will start a three-year term in October as one of three SAE representatives on the Daniel Guggenheim Medal Board of Award. He replaces J. B. Wassall. The other SAE representatives who will continue to serve on the Board are Jerome Lederer and W. F. Ballhaus.

The Directors acted favorably on 121 applications for membership, and also denied membership to 16 applicants.

At the recommendation of the Membership Grading Committee, the Directors approved the following as an addition to the Committee's Guideposts: "A flight engineer is not considered to be practicing the profession of a graduate engineer and, without further technical qualifications, shall be considered qualified for election to Associate grade."

Young European Engineers Can be Tough Competitors

by **Leonard Raymond**, SAE Past President

IN LESS THAN 15 years, war-devastated European countries have made tremendous strides in rebuilding their economies through the will and effort and ambition of free people.

There is no mystery to this achievement. The method is simple and basic . . . hard work, intelligently directed. Hard work starts early in Europe. During the beginning school years the curriculum is much more taxing than ours in the United States — and continues to be so throughout the years of formal education.

In countries less blessed with material advantages, a college education cannot be a luxury. More frequently, it is a sacrifice and an investment in those promising young people who offer the best potential for successful return — to their families and to their country — through future contributions.

There is a common saying in the pugilistic fraternity that a hungry fighter makes the best fighter. Europe has this stronger incentive, since it is so hungry for economic progress.

Another part of the difference in atmosphere is the very great respect in Europe in which European university professors are held. A number of top management and engineering executives, for example, are very proud to be called Professor, a title earned by becoming part-time working professors in nearby universities.

European education (the Latin root means "to lead out") appears more effective in drawing out potential ability than we find in this country. For engineers, it results in a depth and breadth of grounding in the basic sciences and languages which are the envy of American visitors. This greater facility in languages must be seen to be appreciated. It enables our friends and competitors to read needed foreign publications from other countries — an accomplishment of increasing value in this shrinking international world of ours.

On entering industry (take the automotive industry for an example), the young engineer in Europe finds the staffs considerably smaller than in the United States, thus requiring greater versatility. Also, with equipment harder to get, there is more improvising and making do with what is available. This eliminates the wasteful shotgun approach to a problem and puts the engineers more on their mettle to show greater selectivity and ingenuity. Older men in our automotive industry may recall operating under such conditions in the past.

As Boss Kettering pointed out at the dedication of General Motors' great technical center: "It still takes people to make these elaborate new facilities productive." This applies across the board to research, engineering, and production. There is an obverse — probably and adverse — side to this coin, but the current European situation may be a factor on the greater tendency for venturesome introduction of new developments.

Europe's standard of living is definitely on the upbeat. Its forward movement is being aided by increasing success in competing with the United States in world markets. We will have to sharpen our skills, abilities, and productivity . . . and one very important part of this is fuller development of the potential of our engineers-to-be. (This article appeared in the Spring 1960 issue of the SAE Student-Gram.)

"Rumble and Thud" Paper Wins Horning Award for Starkman and Sytz

THE 1959 HORNING MEMORIAL AWARD goes to E. S. Starkman and W. E. Sytz for their paper titled "The Identification and Characterization of Rumble and Thud" . . . which was presented at SAE Summer Meeting just one year ago.

E. S. Starkman is associate professor, mechanical engineering, University of California at Berkeley, where he received his B.S. in 1942 and his M.S. in 1945. He remained with the University as teaching assistant and instructor, and has been associate professor since 1954.

W. E. Sytz received his early engineering training at Vanderbilt University. Before service with the Marine Corps, he was with B. F. Goodrich Co., Coos Bay, Oregon. With his B.S. from Oregon State College, in 1957 he joined California Research Corp. as research engineer in the combustion research group, the position he now holds.

E. S. Starkman

W. E. Sytz

An SAE Journal article based on the Starkman-Sytz paper appeared in the July, 1959 issue . . . and the complete paper is scheduled for inclusion in the 1960 SAE Transactions.

The award ceremony took place during 1960 SAE Summer Meeting at Edgewater Beach Hotel, Chicago — just preceding the regular afternoon session on Thursday, June 9. A. G. Cattaneo, 1959 Horning Award Committee chairman, was to preside at the ceremonies, where presentation of the medals was scheduled to be made by Mrs. Elsie M. Horning, who instituted the award in 1955 in memory of her late husband, and SAE's 1925 president, Harry L. Horning. The purpose of the award is best described by the inscription on the medal: "In acknowledgment of a new contribution to existing knowledge of the art of mutual fuel and engine adaptation."

Serving on the 1959 Award Committee with Chairman Cattaneo were C. M. Heinen and C. E. Cummings.

SAE'ers Featured At FISITA Congress

SIX SAE MEMBERS participated in the 8th International Congress of the Federation Internationale des Societies d'Ingenieurs des Techniques de l'Automobile (FISITA) . . . held at The Hague, May 9–13.

Arrangements made through their respective SAE professional engineering activity committees resulted in the following SAE-member contributions:

Combustion Problems in Gasoline Engines — F. W. Bowditch, GMC Research Laboratories

Development of Automatic Transmission Fluids — L. W. Manley, Socony Mobil Oil Co.

Aerodynamics and the Modern Car — A. L. Haynes, Ford's Engineering Staff

Materials Selection for Automobiles in the USA — Joseph Gurski, Ford's Chemical and Metallurgical Laboratories

The Automobile of the Far Future — A. A. Kucher, Ford's vice president of engineering and research.

Why Is the American Car Built as It Is Built? — Henry L. Brownback, technical counsel for Regie Nationale des Usines Renault

FACTS . . . from SAE literature.

(Except where a charge is specifically indicated, SAE Journal will be glad to supply on request one copy of any of the pieces of SAE literature described. Address "Literature," SAE Journal, 485 Lexington Ave., New York 17, N. Y.)

STRICTLY FOR FUTURE ENGINEERS — or for members who may know of engineering students to whom they may pass it on — is the new folder titled "SAE Student Enrollment." Compiled by the Sections Board's Student Activities Committee, the folder tells the WHY and How of SAE Student Enrollment, and of the many services which SAE has provided for the future engineer.

CHAIRMAN W. J. LUX's Membership Committeemen will find his new "Membership Guideposts" an authoritative reference manual.

It tells of the qualifications for the various membership grades, the grading and election procedures, and lots more of value to those engaged in membership promotion. Section and group membership chairmen will find it particularly useful.

30 PAGES OF BRAND NEW OPENINGS — the largest for any one month in SAE's Placement Service history — were listed in the May "New Openings Bulletin."

The available positions are located throughout the country . . . although weighted slightly toward the Midwest area.

N. Y. Area Students Hear Manganiello

STUDENTS from six colleges in the New York City area were encouraged by E. J. Mangeniello, associate director of National Aeronautic & Space Administration, Lewis Research Center, who stated that underlying all the different engineering specialties and changing technological trends are the same general laws and fundamentals, at the SAE Aeronautic Meeting on "Student's Night," April 6. After touring the missiles and aircraft engineering displays, the students were welcomed by T. B. Rendel, vice-chairman, students, for Metropolitan Section. Mel Friedman, student chairman for College of the City of New York Student Branch introduced Manganiello, an alumnus of CCNY. Manganiello made the following points: . . .

Prime indicators of the tremendous growth in science and technology during the last 25 years include these:

- Currently we are spending 30 times as many dollars on research and development as we were 25 years ago.
- There are 5 times the number of

THIS "BEFORE AND AFTER" STANDARDIZATION example of how the earthmoving and farm equipment industries have benefited through SAE's Cooperative Engineering Program, appears in a "just-out" SAE booklet titled: "How CEP's Program Serves the Earthmoving and Farm Equipment Industries." Shown are the dollar savings realized from just one project undertaken by Subcommittee VIII of the SAE Construction and Industrial Machinery Technical Committee.

YOU'LL . . . be interested to know . . .

IN MID-CONTINENT SECTION'S TERRITORY — which covers the whole state of Oklahoma — there were 184 members as of Jan. 1. Section meetings have been alternating between Bartlesville, Tulsa,

Oklahoma City, Ponca City, Cushing, Stillwater, and Norman. Membership is divided roughly as follows:

Bartlesville, Tulsa, Oklahoma City	142 members
Hugo, Lawton, Poteau, and Holdenville	24 "
Cushing, Stillwater, and Norman	18 "

Because of this distribution of membership and the size of the territory, one Mid-Continent Section member was prompted to make this analysis of his fellow-members' on-the-road travels to meetings:

Should 160 of the membership attend a Section meeting held in . . . . . The number of **one-way** miles traveled per member would be . . . .

Oklahoma City	110
Ponca City	90
Bartlesville	88
Tulsa	79
Stillwater	75
Cushing	68

. . . making Cushing the most desirable meeting location from the standpoint of member-per-miles traveled basis.

With four out-of-towners per car, and one car with one local member . . .

Cushing could expect	42 cars
Ponca City	51
Oklahoma City	63
Bartlesville	70
Tulsa	94

If each member were to go independently to Cushing from . . . . . The total number of miles traveled would be . . . . . .

Tulsa	8,800
Cushing	12,300
Bartlesville	12,600
Ponca City	15,300
Oklahoma City	17,000

The Section member who submitted this analysis concluded by saying: "Regardless of what these figures indicate or what conclusions can be drawn from them — whether from gasoline consumption, total number of miles traveled, or the average number of miles traveled per member, the Mid-Continent Section is unique. It's the birthplace of the SAE National Fuels and Lubricants Meeting . . . and it is continually active and aggressive, even though its members are dispersed throughout the State of Oklahoma." (This is a digest of item in Mid-Continent Section's Bulletin for March, 1960.)

scientists and engineers employed now as then.

- The ratio of scientists and engineers to all workers has increased three-fold. (On an overall basis, one employee out of 50 is an engineer or a scientist, but in highly technical industries like aeronautics one in every 10 is a technical professional.)

Even more significant then these bare statistics is the increasing number of engineers and scientists in top level managerial positions. Corporate management used to be completely dominated by the legal and fiscal professions. But currently, many "executive suites" are occupied by the technical professional.

Aeronautics and its extension, astronautics, provides an excellent illustration of a rapidly changing technology. In 1936 the piston engine was the only aircraft powerplant type. The changing technology then consisted of the struggle for bigger, lighter, and more efficient engines. By the early forties it included more and larger cylinders, better finning for improved cooling, higher compression ratios, higher knock rating fuels-superchargers and intercoolers. Then came the jet engine, the turbojet, the turboprop, the ram jet, and the rocket. Advent of these engine types introduced a major revolution in all parts of the business. New energy types were also developed: nuclear energy and the esoteric high energy borane chemicals appeared on the scene as alternates or additions to the conventional hydrocarbons or fossil fuels. Air speeds increased up to several times the speed of sound and the rocket powered missiles began their climb to ascendancy.

With the dawn of the space age came emphasis on the higher energy chemical rocket propellants, i.e. hydrogen-oxygen and hydrogen-fluorine accelerated consideration of nuclear rockets and introduction of the electric propulsion devices, i.e. ion, plasma, and arc jet rockets.

Often existing facilities can be adapted to meet new needs. To illustrate: the altitude wind tunnel at NASA Lewis Research Center was originally built for research and development on reciprocating engines for World War II aircraft. Today, the wind tunnel investigates and develops components for NASA's Project Mercury.

How can engineers and scientists best meet the changing technology? Courses and books can provide the basic understanding and background in a large number of fundamental scientific areas. But with rapid technological change there is an appreciable time lag between new developments and text books. Various technical societies fill this gap through meetings and publication of technical papers and journals. But the individual must have the am-

bition to partake of the intellectual repast.

A student's choice of a specialty is not particularly important. With the rapid changes in today's technology, there may be as much or more difference within a given specialty over a short time than presently exists between two separate specialties. Many engineers in the aircraft propulsion and other fields have successfully negotiated several significant changes in their technical specialties over a relatively brief span of years.

Sections Plan New Student Activities

TODAY'S STUDENTS will be the technically trained SAE members of tomorrow. Stimulation of interest in SAE on the college campus is an important part of Section activity. This was the main point agreed upon at an Eastern Regional Section Officers Conference held April 4 during SAE Aeronautic Meeting in New York. One meeting each year, it was suggested, should be devoted to students. High school students may be reached through JETS, the Junior Engineering Technical Society, with some 600 high school chapters through the United States.

Technical presentations provide the best Section meetings. This was the answer to the second most stressed question at the Conference: What is the purpose of a Section meeting — to fill a hall with people or to disseminate technical information to an intelligent audience? Quality of future members, it was pointed out, is determined by the quality of Section papers, for every guest may be a potential member.

Other points made at the meeting included:

- Topics which include something of interest to members in separate fields would draw more people to a Section meeting.
- A good speaker is essential for a successful meeting.
- A mutual exchange of meeting announcements between Sections provides a beneficial exchange of ideas.
- The important function of the Section Governing Board is to set up good meetings. Other matters should be subordinated to this function.

The conference, which was moderated by George J. Liddell of Philadelphia Section, was the third of its kind. It was the first to be held on the East Coast. Vancouver, British Columbia was the setting of the first meeting in August 1959. The second opportunity for Section officers to meet was in November 1959 at Chicago.

Membership Chairman Lux Pilots new "Pilot Project"

METROPOLITAN SECTION has already put into operation the new "Pilot Project" which SAE Membership Chairman W. J. Lux has inaugurated . . . and Chicago, Milwaukee, Southern California, Cleveland, and Mid-Continent Sections are about to follow suit.

W. J. Lux

"Pilot Project" is the name of a program designed to interest qualified engineers in SAE membership. . . . It operates basically like this:

After choosing plants with the best membership potential in the territory, the Section or Group Membership Chairman would:

- Meet with SAE Plant Representatives and other influential members there to determine what existing SAE services are best adapted to the work of the plant.
- Design a membership approach on this basis, stressing, of course, the value of SAE as a developer of the individual engineer to his own and his company's benefit.
- Select interested, SAE-minded "contact people" within the plant who will utilize this "approach" . . . and supply the contact people with application blanks and appropriate literature to enable them to do a good job.
- Assist and encourage these "contact people" by following through promptly on their efforts. This can take many forms . . . such as assisting the prospect in filling out his application, helping him to find the required references, and, if necessary, assuming the responsibility of getting the application into the hands of headquarters staff for immediate processing.

'60 Sperry Award to Braddon for "Mark 19 Gyro-Compass"

FREDERICK D. BRADDON, chief engineer, Sperry Gyroscope Co., received the 1960 Elmer A. Sperry Award on May 4, at Franklin Hall in Philadelphia, for his "outstanding contribution to the field of transportation," the Mark 19 Gyro-Compass.

It was the Mark 19 that guided the nuclear submarines Nautilus and Skate under the ice cap at the North Pole . . . and which has since become the basis of navigational reference aboard submarines, guided missile cruisers, and other major combatant vessels of the U. S. Navy.

With an M. E. degree from Stevens Institute of Technology, Braddon joined Sperry in 1929, and has been developing gyros for marine and aircraft automatic pilots, controls, and instrumentation systems ever since. He is the first Sperry employee to have been selected for the Award.

The SAE, with the American Society of Mechanical Engineers, American Institute of Electrical Engineers, and the Society of Naval Architects and Marine Engineers, are the four sponsors.

Frederick D. Braddon

SAE's representatives on the 1960 Board of Award are R. P. Trowbridge and T. P. Wright.

1960 SAE Transactions Will Include 70 Meetings Papers

THE 1960 edition of SAE Transactions will be published in August. It will include about 70 papers presented at Society meetings during 1959 and early 1960.

Prices of the book are: $3 to members, $7 to libraries and U. S. Government agencies, and $10 to nonmembers. Foreign prices are: $3 to members, $8 to libraries, and $11 to nonmembers.

The papers selected by the Readers Committees are:

Radioactive Cylinders — A Tool for Wear Research — by **W. C. Arnold, V. T. Stonehocker, W. J. Braun and D. N Sunderman**

Engine Blocks and Their Components in Aluminum Die Casting — by **A F. Bauer**

Reduction of Air Pollution by Control of Emission from Automotive Crankcases — by **P. A. Bennett, M. W. Jackson, C. K. Murphy and R. A. Randall**

Road Performance of a Comprex Supercharged Diesel Truck — by **Max Berchtold and H. P. Gull**

Correcting Horsepower Output — A Realistic Method for Diesel Engines — by **A. K. Blackwood and W. J. McCulla**

Hydrodynamic Split Torque Transmission — by **Peter Bioch and Raymond C. Schneider**

Hydrostatic Transmissions for Vehicles — by **E. H. Bowers**

Dynamic Balancing of Rebuilt Engines and Driveline Components — by **Ralph T. Buscarella**

Physical and Chemical Ignition Delay in an Operating Diesel Engine Using the Hot-Motored Technique — Part II — by **C. W. Chiang, P. S. Myers and O. A. Uyehara**

Preliminary Design Considerations for the Structure of Trisonic Transport — by **M. G. Childers**

Prediction in New Metal Joining Processes — by **John J. Chyle**

Non-Air-Breathing Auxiliary Powerplants — by **D. L. Cochran, A. T. Biehl, D. R. Sawle, M. R. Gustavson and A. M. Taylor**

Oxidation Stability, Shear Stability and Rubber Swell Properties of Automatic Transmission Fluids — by **H. E. Deen and C. M. Stendahl**

Seal Testing To Establish Quality Control Specifications Can Reduce "Leakers" — by **Robert L. Dega and James D. Symons**

IH High-Speed Lightweight Diesels — by **A. F. Dewsberry, C. P. Bozos and J. B. Reeves, Jr.**

The Expanding Polymer Horizon — by **J. H. Du Bois**

Basic Design of Turbochargers for Diesel Engines — by **Hans Egli**

Radioisotopes in Research — by **W. P. Evans and E. W. Landen**

Optimum Joint Design for High-Temperature Honeycomb Panels — by **Frank J. Filippi and Boris Levenetz**

The Design of a Truck for Better Ride and Handling — by **H. O. Flynn**

G M R Stirling Thermal Engine — Part of the Stirling Engine Story — 1960 Chapter — by **Gregory Flynn, Jr., Worth H. Percival and F. Earl Heffner**

Electric Propulsion — Measurements with a small Thrust Plasma Generator — by **B. Gorowitz and B. W. Harned**

Radiotracers Reveal Engine Wear During Detergent Oil Filtration Study — by **Harry Halliwell**

Some Development Problems with Large Cryogenic Propellant Systems — by **Daniel A. Heald**

Application of the Cumulative Fatigue Damage Theory to Practical Problems — by **William F. Hofmeister**

Computer-Based Selection of Balanced-Life Automotive Gears — by **George J. Huebner, Jr.**

Compressive Failures in Transmission Gearing — by **G. E. Huffaker**

Developing Transaxle Fluid — by **Norman A. Hunstad, Robert A. Wilkins, Robert E. Osborne and Ellard D. Davison**

Brake Drums — Investment for Safety and Profit — by **Paul G. Hykes and Clarence A. Herman**

Spark Plug Misfiring — Mechanism Studies — by **H. P. Julien and R. F. Neblett**

Horsepower Rating for Commercial Vehicle Brakes — by **John H. King and Alex F. Stamm**

Ways of Improving Take-off and Landing — by **F. W. Kolk**

The First Year of the Jet Age — Reflections — by **F. W. Kolk**

Electric Propulsion Systems — by **Victor P. Kovacik and Daniel P. Ross**

Material and Structural Damping for Vibration Control — by **B. J. Lazan**

Possibility of "Spare Tire Elimination" by Use of Dual Compartment Tires — by **Walter Lee**

The Development of Refractory Sheet Metal Structures — by **Alan V. Levy and Saul E. Bramer**

The Machining of Ultra Strength Alloys — by **John Maranchik, Jr., J. V. Gould and P. R. Arzt**

The Effect of Residual Stresses Induced by Strain-Peening upon Fatigue Strength — by **R. L. Mattson and J. G. Roberts**

Torsionally Resilient Drive Lines — by **P. J. Mazziotti**

How Good is Testing? A Correlation of Customer, Laboratory, and Proving Ground Experience — by **William A. McConnell**

Electric Drive for Off-Highway Vehicles — by **H. J. McLean and H. Vitt**

High-Temperature Materials and Their Heat-Treatment for Antifriction Applications — by **O. W. McMullan**

Rating Transmissions from Highway Requirements and Vehicle Specifications — by **F. C. Meldola**

Relaxation of Residual Stresses Due To Fatigue Loading — by **JoDean Morrow, A. S. Ross and G. M. Sinclair**

Hydrostatic Transmissions — by **P. C. Mortenson**

Refractory Nonmetals for Use in Hypersonic Aircraft — by **John M. Nowak**

The Use of Radioactive Tracer Techniques to Determine the Effect of Operating Variables on Engine Wear — by **B. A. Robbins, P. L. Pinotti and D. R. Jones**

A Universal Means for Rating Diesel Engines for Deposits and Wear — by **F. A. Robbins, L. G. Schneider and G. H. Shea**

Turbine Fuel Thermal Stability, CFR Coker and Flight Evaluations — by **J. D. Rogers, Jr.**

Nuclear Rockets for Interplanetary Propulsion — by **Frank E. Rom and Paul G. Johnson**

Design Procedure for Vibration Isolation on Non-rigid Supporting Structures — by **Sheldon Rubin**

Radiation from Flames in Gas Turbine Combustors — by **R. M. Schirmer, L. A. McReynolds and J. A. Daley**

A Study of Self-Contained Starting Systems for Turbojet and Turboprop Engines — by **Henry R. Schmider and John H. Ferguson, Jr.**

New Elastomers Break Old Barriers — by **Ralph P. Schmuckal**

Automatic Transmission Fluid Viscosity at Low Temperature and Its Effect on Transmission Performance — by **Theodore W. Selby**

Current Trends in Storable Propellants — by **J. Silverman and S. A. Greene**

Transistor Switched Ignition Systems — by **G. E. Spaulding, Jr.**

The Identification and Characterization of Rumble and Thud — by **E. S. Starkman and W. E. Sytz**

Engine Rumble — A Barrier to Higher Compression Ratios? — by **R. F. Stebar, W. M. Wiese and R. L. Everett**

Economics of Heavy-Duty Brake Design and Maintenance — by **R. K. Super**

High Energy Accelerators — by **Keith R. Symon**

Radiation Effects Studies for the Development of Radiation-Resistant Aircraft Subsystems — by **J. J. Tierney**

Properties of Silicone Rubber for High-Temperature Static Seals — by **H. E. Todd and J. F. Miazga**

Properties of Asbestos Reinforced Laminates at Elevated Temperatures — by **Norman E. Wahl**

Rolls-Royce Diesel Engines — by **R. H. Whiteside**

The Development of Two New Allis-Chalmers Diesel Engines — by **Hans L. Wittek**

Soviet Agricultural Tractors and Equipment — by **Wayne H. Worthington**

SAE LETTERS FROM READERS

From:
Howard G. Kurtz (A'57)
Handy Associates, Inc.
405 Park Ave.
New York 22, N. Y.
Dear Editor:

In most fields of engineering — including the areas covered by SAE — there is room for a new category . . . **survival technology**, as a counterpart to war technology. Today, with each new scientific insight, technical experts go to work to adapt this new knowledge to the tactics of war.

There is urgent need for new task forces of scientists and engineers committed to research and development in survival technology, developing the instrumentation, the safety systems, the communications networks, the technological tactics to be used in an eventual enforceable world safety organization to make certain that no one in the future can use this new knowledge to threaten, or to wage war. Rather than a dream, this has now become imperative . . . or there will be no future.

The end of a national security: We are now rapidly passing the point of no return, beyond which, even if military budgets are doubled, or tripled, or quadrupled, for unlimited research and development and experiment and production for national defense, **no nation, ever again, can assure safety or security for its people against modern scientific enemy attack!**

The future of any one nation can be regained in the future only when the future security of all nations can be secured simultaneously, in a single world security organization of some kind. How can a professional society refuse to be concerned with this question of the public safety and national security?

Without diminishing engineering effort in military technology, can't there be technical papers on subjects of **enforceable military safety techniques?**

Can't there be annual awards and fellowships for engineers making significant new contributions to the **technology of survival?**

Can't engineering schools be encouraged to open new curricula that future engineers may choose to dedicate themselves to the **engineering of safety against war?**

Can't science and engineering compete across the world as well toward the goal of the survival of mankind, as they have toward the goal of wiping man off the earth in war?

Can't we begin to change the Cold War into a **Design Competition for a War-Proof World?**

Are there engineers so delighted with their personal incentive incomes in the defense industries, that they would vote to keep the society from investigating the new field of survival technology?

I hope other SAE members will write their personal reactions, pro and con, to you.

●

From:
R. W. Thomas (M'36)
Director of Transportation
Quality Bakers of America Cooperative, Inc.
New York, N. Y.
Dear Editor:

I note in the March 1960 issue of the SAE Journal, pp. 78–80, a symposium on "Truck Wheel and Tire Unbalance Getting the Works."

It seems to me that the main point was missed by all of the speakers, as they confined all of their comments to wheel and tire expense.

Our organization has been pushing a campaign for wheel balancing on all front wheels of our trucks for a number of years. It's purpose has not been to save tires, but primarily for safety, and particularly because of the excessive vibration resulting from imbalance, which caused the front ends of ¾-ton, 1-ton, and 1½-ton trucks to entail excessive maintenance. In any of these light vehicles there is only from 5 to 10% of the weight on the front axle, and the result is that radiators particularly, and other items tend to shake loose. This, to my mind, is the real justification for wheel balancing, rather than any conceivable saving in wheels and tires.

●

From:
J. B. Scannell, Chief Engineer
Greene, Tweed & Co.
North Wales, Pa.
Dear Editor:

It has come to our attention that the SAE Journal carried, in May 1959, an article entitled "Backup Ring Design Affects O-ring life," based on a paper by C. E. Hamlin of Autonetics.

Fig. 1A of this article shows the delta-type backup as utilized with an O-ring. This backup is covered by U. S. Patent 2,420,104, to which Greene, Tweed & Co. holds exclusive license.

You can well appreciate the difficulties which arise when such an illustration is published without calling attention to patent coverage. We are equally well aware that you are not able to screen all papers and articles published to avoid situations of this nature.

However, we would appreciate it if you could make known to your readers the facts concerning the triangular delta backup in order that our position will not be further undermined.

●

From:
James M. Lewis
922 East Jefferson St.
Fort Wayne, Ind.
Dear Editor:

My experience with the SAE Placement Service and the SAE Journal listing of 1960 Engineering Graduates has been above average (December, 1959, pp. 103–108).

I received, by the middle of February, a total of 24 inquiries from companies in all phases of automotive engineering. I was invited for personal interviews to six of these companies and have accepted employment with one of them. I previously had tried to contact several of these companies on my own, but had no luck in doing so. I noticed that the men I talked to had interest and respect for the fact that I was affiliated with SAE.

I greatly appreciate the opportunity of having participated in this placement program and I hope that you will continue to make it available to college students. I know many men in our SAE Student Branch at Indiana Technical College who were sorry that they had not taken the trouble to take advantage of this service. I have supplied them with the inquiries that I didn't follow up.

May I take this opportunity to thank you and the members of the SAE Placement Committee for making this outstanding service available to me and other college students.

●

From:
A. L. Stewart, Director
Standards Association of Australia
Sydney, Australia
To: Editor, SAE Handbook:

We have just received our copy of the 1960 SAE Handbook.

The SAE Standards have become so much used by industry in this country that scarcely a day passes without this Handbook answering some query from the industrial public or one of our many committees.

According to our librarian it is one of the most valuable and frequently used reference books in our library.

Many thanks.

. . . is theme of 11th Annual Earthmoving Industry Conference

THE ELEVENTH ANNUAL EARTHMOVING INDUSTRY CONFERENCE drew more than 1800 participants desirous of Seeing Ahead in Earthmoving. Present were representatives of the designing, contracting, manufacturing, operating, selling, and administrating segments of the earthmoving industry. Technical presentations designed to whet their appetite for knowledge included: Construction Machinery Requirements of the Corps of Engineers; The AASHO (American Association of State Highway Officials) Road Test — What It Taught Us; High Durability Electrical Equipment for Earthmovers; Electrical Remote Control Systems; Diesel Engine Cold Starting; Role of Computers in Earthmoving; Development and Potential Applications of the Gas Turbine; The Place of the Gas Turbine in Off-Highway Equipment; The Fuel Cell Powerplant; and a panel on Earthmoving Equipment Requirements — The Next Decade. Serving on the panel were:

L. P. Gilvin, Gilvin-Terril, Inc.; C. F. Replogle, C. F. Replogle Co.; E. D. Williams, Williams & Bessert; G. G. Werner, Jr., Merritt-Chapman & Scott Corp.; W. J. Troup, Jr., Troup Bros., Inc.; and M. A. Robinson, Morrison-Knudsen Co., Inc.

The Conference was held in Peoria, Illinois — the earthmoving capital of the world — and was a success because of the excellent participation of Central Illinois Section members and the many associated companies, who encouraged attendance and presentation of papers.

Conference chairman, M. C. Nuel welcomed the registrants and Rev. Father Walter Buche gave the invocation.

Senator Jennings Randolph of West Virginia added both humor and serious thought in his speech at the banquet. The Senator re-emphasized the responsibility of citizens to get their personal views to their Congressmen. On the humorous side, Randolph pointed out some of the character changes that many Presidential candidates undergo as they become serious campaigners.

The keynote speaker was Lt.-Gen. E. C. Itschner. Gen. Itschner reviewed some of the history of early earthmoving projects and showed how modern projects are handled in a much different way. By way of illustration, the Fort Peck Dam built in 1930 was an earthfill job which was constructed largely with a hydraulic dredge. Well over a million cubic yards were handled in this manner. In comparison, the Oahe Dam, completed recently, was built with highly mobile earthmoving equipment.

The new Titan missile bases will require the movement of over 4,000,000 cu yd. Itschner suggested that the military would like to see new machines built with more replaceable components along the much publicized "black-box concept." The General concluded by inviting suggestions from industry concerning military construction and transportation.

The six objectives of the Conference continue to be:

1. To publicize the high order of engineering activity in the development of earthmoving machinery.
2. To serve the engineers who are locally engaged in designing and developing earthmoving equipment.
3. To bring to the younger engineers a meeting of national character.
4. To bring engineers of the Central Illinois area in contact with engineers of wide experience and knowledge in the industry.
5. To promote in younger engineers a desire to belong to a technical society interested in promoting engineering activities.
6. To promote the general welfare of the industry by the publicity to be obtained therefrom.

It is felt that all of the objectives were achieved at this year's Conference.

ELEVENTH ANNUAL EARTHMOVING INDUSTRY CONFERENCE COMMITTEE. Rear (l-r): I. L. Joslin, secretary; R. Lenich, publicity; J. H. Babbitt, Jr., finance; L. B. Brown, housing. Front (l-r): R. H. Kress, program; D. F. Webster, arrangements; M. C. Nuel, general chairman; and J. A. Drais, treasurer.

KEYNOTE SPEAKER at the 11th Annual Earthmoving Industry Conference was Lt.-Gen. E. C. Itschner, Chief of Engineers, U. S. Army. Here he discusses construction machinery requirements of the Corps of Engineers with W. E. Chastain, Sr. (left) and E. E. Isgren (center).

Chastain spoke at the meeting on the AASHO (American Association of State Highway Officials) Road Test — What It Taught Us. The construction of the test facility was under Chastain's supervision.

E. E. Isgren, executive vice-president of LeTourneau-Westinghouse Co. was a technical chairman at the meeting.

At the Earthmoving Industry Conference . . .

AASHO Road Test — What It Taught Us by **W. E. Chastain, Sr.**, Illinois Division of Highways (Paper not available)

High Durability Electrical Equipment for Earthmovers by **W. C. Edmundson,** Delco Remy Division, GMC (**S243**)

Electrical Remote Control Systems by **J. T. Osterman,** Electric Auto-Lite Co. (**S238**)

Diesel Engine Cold Starting by **L. P. Atwell,** Electric Auto-Lite Co. (**S241**)

Role of Computers in Earthmoving by **Basil Mikhalkin,** Bendix Aviation Corp. (**S240**)

Development and Potential Applications of the Gas Turbine by **L. J. Nuttall,** General Electric Co. (**S244**)

Place of the Gas Turbine in Off-Highway Equipment by **J. M. Stephenson,** Lycoming Division, Avco Corp. (**S239**)

The Fuel Cell Powerplant by **Dr. H. K. Ihrig,** Allis-Chalmers Mfg. Co. (**S253**)

Papers are available through SAE Special Publications Department. Prices: 50¢ a copy to members; 75¢ a copy to nonmembers.

BANQUET SPEAKER, Senator Jennings Randolph of West Virginia (left), smiles as he discusses Take Time for Laughter speech with R. W. Rand, chairman, Central Illinois Section.

SAE MEMBERS

WILLIAM F. LeFEVRE has been appointed director of advanced product research to head an expanded research program at White Motor Co. This program will include the study of all forms of transportation to guide White's long-range product development program.

LeFevre served Freightliner Corp. as chief engineer and chief engineer-research from 1950 to June 1959. He had been manager of research at Fruehauf Trailer Co. since June, 1959.

Lefevre

Raymond

Heimann

ARTHUR E. RAYMOND retired June 1 as senior vice-president of engineering at Douglas Aircraft Co., Inc., after 35 years of productive service.

He is a past Director of SAE.

EDWARD HEINEMANN has been named to take charge of operations in Europe for Douglas Aircraft Co., Inc. Heinemann has made many contributions since he joined Douglas in 1926, including the present A4D, which has been nicknamed "Heinemann's Hot Rod."

FREDERICK C. MATTAEI, JR., vice-president of research and development for American Metal Products Co. since 1958, has been named executive vice-president of the company.

DR. R. P. DINSMORE, vice-president in charge of research and development of Goodyear Tire & Rubber Co., has been elected to the Goodyear board of directors.

IDEN F. RICHARDSON has been appointed a vice-president of Hughes Aircraft Co. He will continue to serve as manager of the company's commercial products activities, a position to which he was named in October 1959.

EMIL O. WIRTH has been appointed staff assistant to the assistant group executive of Bendix Products Division of Bendix Corp. He will concentrate on cost reduction.

He was most recently factory manager of the Landing Gear Division in charge of quality control and manufacturing of aircraft struts, wheels and brakes, and nuclear mechanisms.

Wirth is a past chairman of SAE Chicago Section.

SHELDON G. LITTLE has been named director of the newly created product reliability department at General Motors Corp.'s Truck and Coach Division. Little was previously assistant chief engineer of the division.

DONALD J. LaBELLE has been named to succeed **Sheldon G. Little** as assistant chief engineer of GMC Truck and Coach Division. He will report to **C. V. Crockett,** chief engineer of the division, and will be responsible for truck engine, chassis and body engineering developments. Previously he was truck engineer.

ROBERT E. FIELD has been appointed to succeed **Donald J. LaBelle** as truck engineer for GMC Truck and Coach Division. Formerly he was administrative engineer.

Mattaei

Richardson

Wirth

Little

LaBelle

Field

WILLIAM M. HOLADAY has resigned as chairman of the Civilian-Military Liaison Committee. In his letter of resignation to President Eisenhower, Holaday recalled that "legislative changes now pending recommend dissolution of the liaison committee." In testimony before Congress, Holaday had earlier said that his Committee had become "little more than a post-office" serving the civilian and military space groups. . . . Accepting the resignation, the President commended Holaday, writing: "Through your association with these activities, you have helped to solve many of the intricate problems for which no precedents have existed."

THOMAS V. JONES, president of Northrop Corp. since May 1959, has also been named the company's chief executive officer.

FRANK O. RILEY has been appointed general manager of Ternstedt Division of General Motors Corp. Riley joined General Motors in 1933 and was most recently director of product engineering for the Ternstedt Division.

FREDERICK J. HOOVEN has been appointed to the newly created position of technical assistant to the chief engineer of Ford Division, Ford Motor Co. Previously he was executive engineer of advanced cars.

JESSE W. RICHARDS succeeds **Frederick J. Hooven** as executive engineer of advanced cars at Ford Division, Ford Motor Co. His previous position was department manager.

WILLIAM C. HEATH, manager of industrial products at Solar Aircraft Co., has been named manager of the company's newly formed Industrial Products Division.

ROBERT S. PLEXICO has retired as chief truck design engineer at Chevrolet Motor Division, General Motors Corp. Plexico joined Chevrolet Motor Division in 1934 and has been associated with a number of modern developments in passenger cars, commercial and military vehicles. Prior to joining GMC he served Anderson Motor Co., Warner Gear Co., and Willys-Overland.

Executive Changes at Chrysler Corp.

LESTER L. COLBERT, formerly president of Chrysler Corp., has become chairman of the board of directors and chief executive officer. **WILLIAM C. NEWBERG** has been named president of the corporation.

Colbert

Newberg, who has been executive vice-president since 1958, will be chief operating officer.

Newberg and Colbert has been closely associated since World War II when Newberg was chief engineer of the Dodge Chicago plant and Colbert was general manager.

Newberg

Newberg succeeded Colbert in 1951 as president of the Dodge Division.

RUSSELL FRANKS has retired as manager of Marketing Research Division at Union Carbide Metals Co., a division of Union Carbide Corp. He will continue to serve the company in a consulting capacity.

Franks has served Union Carbide over 40 years, and has been credited with many metallurgical developments in stainless and alloys steels. He started in the Corporation's Research Laboratories and, after serving in various capacities, was appointed chief metallurgist in 1943. In 1946 he was transferred to the predecessor of Union Carbide Metals Co. and in 1950 became manager of development. He was named manager of the Marketing Research Division when it was organized in 1956.

ARTHUR E. MILLER, director of research at Scott Aviation Corp., addressed the Thirtieth Annual Convention of the Greater New York Safety Council on March 29 in New York City, demonstrating the fire hazards of gaseous oxygen.

LEO M. CHATTLER has been appointed general manager of Raymond Atchley, Inc., a subsidiary of American Brake Shoe Co. Previously he was employed by Chance Vought Aircraft, Inc. as manager of electro-mechanical products for Vought Electronics Division.

Chattler is chairman of SAE A-18 Technical Committee of the Aircraft, Missile and Space Vehicle Flight Control Systems and is a member of SAE A-6 Committee on Aircraft and Space Vehicle Hydraulic and Pneumatic Systems.

THOMAS J. GILLICK, JR. has been appointed to the newly created position of manager of product application and engineering at American Felt Co.'s Marketing Division.

As manager of their engineering and Research Division and a member of their New Products Planning and Development Committee, Gillick has been actively concerned in developing new products and applications for wool and synthetic fiber felts.

—continued—

Heath

Plexico

Frank

Miller

Chattler

Gillick

Lockheed Vice-Presidents Advance

Monesmith

Haddon

BURT C. MONESMITH, vice-president and general manager of Lockheed Aircraft Corp.'s California Division for eight years, has been named corporate vice-president for manufacturing, a newly established position for company wide guidance on production functions.

M. CARL HADDON, who has been serving Lockheed Aircraft Corp. as vice-president and general manager of the Electronics and Aviations Division, has been named to succeed **Burt C. Monesmith** as vice-president and general manager of the California Division.

FRED T. MILLER has been named vice-president and general manager of Borg-Warner Controls, a newly formed Division of Borg-Warner Corp.

The new division, which is headquartered at Santa Ana, Calif., will maintain close liaison with Western Hydraulics, Ltd., subsidiary of Borg-Warner.

Miller was formerly technical assistant to the president of Western Hydraulics.

FRED O. HOSTERMAN, president and general manager of Western Hydraulics, Ltd., adds responsibilities as president and chief executive officer of Borg-Warner Controls.

LELAND E. BOREN, president of Pierce Governor Co., Inc., has become president of Pierce-Pickering Governor Co., which was recently formed by the acquisition of the former Farris Pickering Governor Co. by Pierce Governor Co.

ROBERT E. VALK has been appointed general manager of manufacturing for Automotive Division of Essex Wire Corp. Previously he was vice-president and group executive of Electric Auto-Lite Co.

DEAN C. REEMSNYDER has been named project engineer for the engineering department of New Devices Laboratories, Thompson-Ramo-Wooldridge, Inc.

Reemsnyder joined New Devices in 1956 and has been assisting in analysis and design of nuclear auxiliary power units.

RONALD B. CHRISTIANSEN has been named field fleet service manager of Plymouth-De Soto-Valiant Division of Chrysler Corp. Christiansen joined Chrysler Corp. in 1936 as a representative for the Central Service Division, and was most recently fleet service manager for the Fargo Division.

D. G. PROUDFOOT, vice-president, Pennzoil Division, South Penn Oil Co., has retired. He was a long time member of SAE Fuels and Lubricants Technical Committee and served as vice-chairman. He was also vice-chairman of Pittsburgh Section for a number of years.

Proudfoot and his wife are taking an extended trip overseas.

HARRY D. HALL has been appointed director of manufacturing development at General Motors Corp. Previously he was chief engineer of manufacturing development. He joined the Manufacturing Staff at GM Technical Center three years ago.

RONALD A. FEATHERSTONE has been named to succeed **Harry D. Hall** as chief engineer of manufacturing development, General Motors Corp. He had been staff engineer in manufacturing development.

P. G. SMITH has been named executive vice-president of Royal Industries, Inc. Formerly he was executive vice-president of Airaterra and concurrently vice-president and general manager of Roylyn, Inc.

JOSEPH GESCHELIN, Detroit Editor, Chilton Publications will present a paper on management of cutting fluids at a symposium at the Annual Meeting of ASTM in Atlantic City, N. J., the last week in June.

CARL E. WIDELL has been named vice-president in charge of marketing at Wagner Electric Corp. He will be responsible for overall marketing activities of electrical apparatus and automotive braking equipment divisions.

DR. FREDERICK J. PORT has been named vice-president at the Automotive Division of Electric Storage Battery Co. He has been general manager of the division since 1958.

F. J. STRNAD has been named vice-president and chief engineer for Link-Belt Speeder Corp. Previously chief engineer he joined Link-Belt Speeder in 1945 after eleven years experience in engineering and field service for Link-Belt Co.

Valk

Reemsnyder

Christiansen

Widell

Port

Strnad

JAMES M. CHANDLER, section supervisor of test engineering at Ford Motor Co., has been elected chairman of the Vehicle Combustion Products Committee of the Automobile Manufacturers Association succeeding **CHARLES M. HEINEN**, assistant chief engineer for chemical engineering development at Chrysler Corp.

DR. RALPH T. HALSTEAD has been appointed to the newly created position of sales manager for friction materials of Johns-Manville Corp.'s Packings and Friction Materials Division.

Dr. Halstead joined Johns-Manville in 1931 as research chemist in friction materials and packings department. In 1940 he became section chief of friction materials, and in 1944 manager of Packings and Friction Materials Research Department.

WINFORD B. HICKMAN has been appointed to the new position of chief product engineer for Clark Equipment Co.'s Brown Trailer Division. Hickman joined Brown Trailer Division in 1959 as product engineer. Prior to that he served seven years with Dorsy Trailers as design engineer, and chief research and development engineer.

SAE Father and Son

G. RALPH STROHL (right) and his son, **H. FREDERICK STROHL** are shown at the Autocar Division of White Motor Co. where they are employed. H. Frederick Strohl, a graduate of Haverford College, is technical service manager, and his father is director of research. The senior Strohl is a past chairman of SAE Philadelphia Section.

NORMAN GECO is now head of Geco Sales Engineering Products, an engineering manufacturers representative concern selling to aircraft, missile, marine and industrial firms in Calif. The company is set up to meet the needs of these industries for high energy products.

Formerly Geco was western district sales manager for Gits Brothers Mfg. Co.

ROBERT PADGETT has been named assistant chief project engineer for Production Turbines Engineering Division of Solar Aircraft Co., reporting to **A. D. Zakarian**, chief project engineer. Padgett joined the Production Engineering Division of Solar in 1950 after graduating from Worcester Polytechnic Institute.

LEONARD J. GALATI, formerly with Delta Air Lines in Atlanta, has joined Southern Airways, Inc. as supervisor of aircraft engineering.

JOSEPH D. KODY has been appointed chief engineer of the Research and Engineering Division of Imperial Brass Mfg. Co. Kody joined Imperial Brass in February 1959. He was formerly associated with the Ford Motor Co. in a supervisory capacity for design engineering.

A. VANCE HOWE has joined Highway Trailer Co. as vice-president of eastern sales.

Howe served Fruehauf Trailer Co. for the past 15 years and was a key figure in their Fleet Sales Division. Prior to Highway Trailer he was manager of Fruehauf's Container Division.

KARL CHALMERS has been appointed product merchandising manager, Service Parts Division of Electric Autolite Co. Previously he was sales manager of the Canadian Parts and Service operations. He is a past chairman of SAE Ontario Section.

WILLIAM C. SCHUSTER, previously district manager, is now fleet sales engineer for Perfect Circle Corp.

JAMES M. MARZEN has joined the staff of the Whiting laboratories of Standard Oil Co. of Ind. In his new position he will carry out studies on the combustion of gasoline in automobile engines. He was previously associated with Chrysler Corp.

LESTER L. NIGHSWONGER has become senior engineer at John Deere Research & Engineering Center, Deere Mfg. Co. Formerly he served Beech Aircraft Corp. as senior design engineer.

GEORGE A. KOZLOFF has become director of engineering for Chrysler Motors, Ltd. in Surrey, England. Formerly he was manager of engineering for Chrysler Corp.'s International Operations.

continued on p. 114

Hickman | Geco | Padgett | Galati | Kody | Howe

Rambling . . .

Through The Sections

For articles based on material drawn from Section papers in this issue see:

pp. 36 & 80 . . .
. . . from **METROPOLITAN** papers
p. 52 . . .
. . . from a **CENTRAL ILLINOIS** earthmoving paper
p. 95 . . .
. . . from a **ROCKFORD-BELOIT** paper
p. 96 . . .
. . . From a SOUTHERN **CALIFORNIA** paper
p. 130 . . .
. . . from a **MID-MICHIGAN** paper
p. 133 . . .
. . . from a **BRITISH COLUMBIA** paper

EARLY AUTO BUGGIES usually had red wheels to identify them as "horseless carriages" — not buggies from which the horse had casually departed, Murray Fahnestock humorously stated at **CHICAGO SECTION** April 12.

RUMBLE is a special type of preignition condition occurring at high speeds and is characterized by severe high frequency vibration. The destructive magnitude of the unbalanced forces is such as to cause extensive engine damage in a very short time, Frank A. Suess, director of technical services, Continental Oil Co. told **KANSAS CITY SECTION** April 21.

FUEL MIXTURES used in competitive races are determined mainly by intuition, according to **Douglas Kline**, winner of the technical papers contest between students from Parks College and Missouri School of Mines & Metallurgy which is held annually at **ST. LOUIS SECTION.**

Kline, a senior at Missouri School of Mines & Metallurgy, is interested in motorcycle hill climbing and told in his paper "Competition Fuel Testing on a C.F.R. Engine" of his research to bring science into the mixing of motorcycle racing fuels.

John Wake, a graduating senior at Missouri, won second place with his paper "Radiation Shielding" in which he developed the formula for determining cost of a lead cover for an atomic engine, such as might be used in the car of the future.

Denis Tsao, a Parks Student, placed third. His paper "Introduction to Magnetohydrodynamics" told of a new concept which involves the making of gases electrically conductive so they can be set into motion by the principle of motor action.

Richard Dyer (above, right), of Lockheed Aircraft Corp., spoke at **NORTHERN CALIFORNIA SECTION, SOUTH BAY DIVISION** April 5. He is greeted by Forest Fingerle, vice-chairman, South Bay Division.

ALL FEDERAL POST OFFICES built after January 1, 1960 are to be equipped with bomb shelters adequate to house the workers normally on duty and additional persons present on business, Col. E. R. L. Doty, director of the Pacific Area, Office of Civil Defense Mobilization told **HAWAII SECTION** April 19.

The City Hall of Honolulu will be equipped with an equal shelter. In addition, plans have been made to construct an underground storage facility in Honolulu adequate to store food and supplies for a period of six months.

INJECTORS developed by Silver Power Fuel Injection Service operate for about 150,000 miles, Q.B. Jervis, owner of the company, told **SOUTHERN CALIFORNIA SECTION** March 14.

The fuel system is basically comprised of a gear type pump supplying fuel to a manifold, similar to the common rail, with injectors supplied from the manifold. Injector plunger travel is constant. Fuel supply to each injector is dependent on pressure in the manifold which is regulated by the throttle.

Almost a DOZEN MILES OF CONVEYOR BELTS were observed by student members from **CCNY STUDENT BRANCH** as they toured Ford Motor Co.'s Mahwah, N. J. plant.

Watching from key locations, they saw the following processes which comprise the 91/2 hr operation of mass-producing automobiles: Parts from manufacturing plants are unloaded and welded into units. After welding, the body is cleaned, phosphate coated, metal finished, and painted by hooded workers in paint booths. Oven baking adds a hard and glossy finish.

During the "trim line" operation, workers swarmed over the moving units, fitting cloth to the roof, sliding sheets of glass into windows, and mounting hardware, mirrors, visors, gages and clocks — in a few minutes.

On a parallel sub-assembly line, frames are started and springs, spindles, drums, brake linings and pedals installed. Pre-tested engines are placed on the line according to production line-up. A hoist lowers the right body on the corresponding chassis. The front end is decked, wheels and cushions added, headlights focused, steering adjusted — and the assemblage is completed.

SAE NATIONAL MEETINGS

1960

- June 5–10
  Summer Meeting, Edgewater Beach Hotel, Chicago, Ill.

- August 16–19
  National West Coast Meeting, Jack Tar Hotel, San Francisco, Calif.

- September 12–15
  National Farm, Construction and Industrial Machinery Meeting (including production forum and engineering display), Milwaukee Auditorium, Milwaukee, Wis.

- October 10–14
  National Aeronautic Meeting (including manufacturing forum and engineering display), The Ambassador, Los Angeles, Calif.

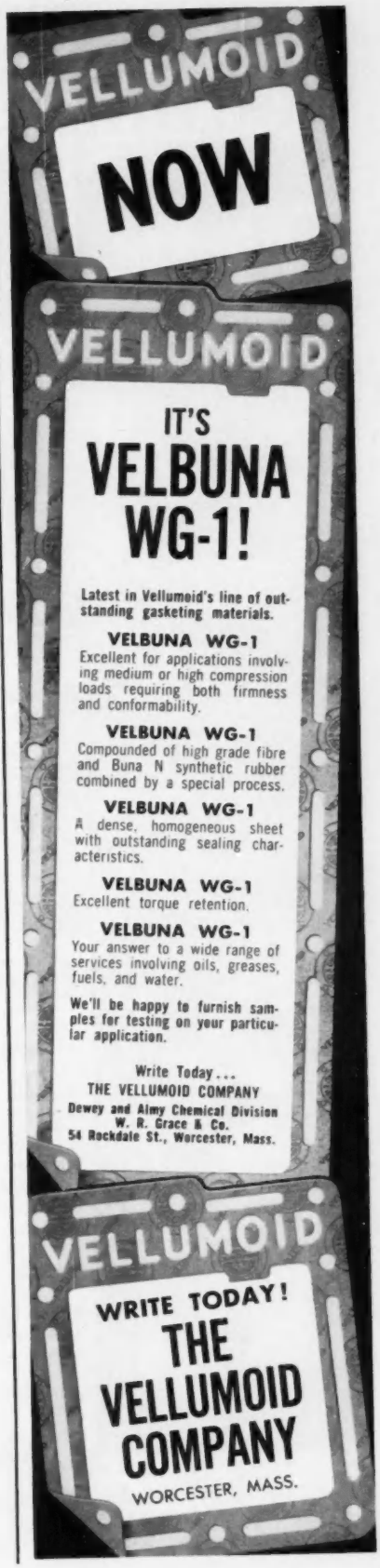
- October 25–27
  National Transportation Meeting, Hotel Leamington, Minneapolis, Minn.

- October 31–November 2
  National Powerplant Meeting, Hotel Cleveland, Cleveland, Ohio.

- November 3–4
  National Fuels and Lubricants Meeting, The Mayo, Tulsa, Okla.

1961

- January 9–13
  SAE International Congress and Exposition of Automotive Engineering (including engineering display), Cobo Hall and Convention Arena, Detroit, Mich.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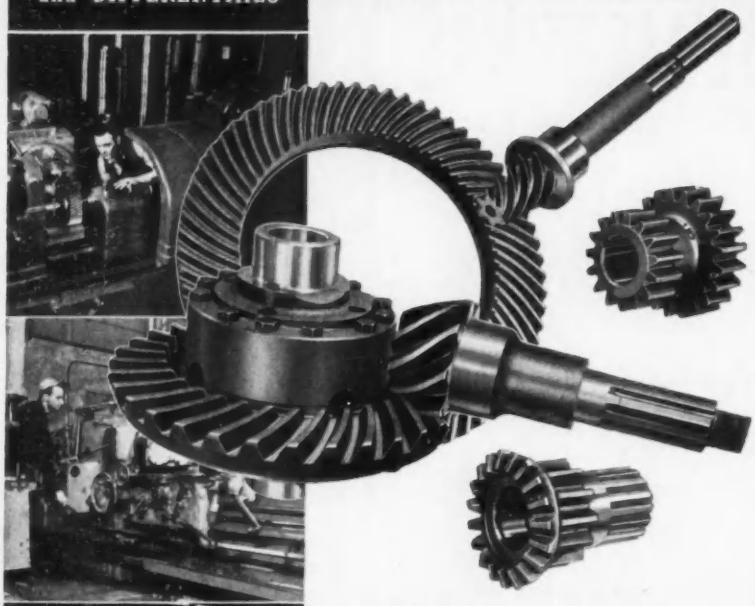

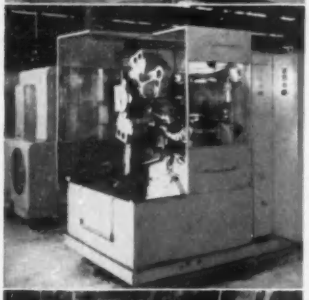

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SAE Members

continued from p. 111

JAMES W. MASSEY has joined the AiResearch Mfg. Co. of Arizona as senior project engineer. Previously he served Beech Aircraft Corp. as chief project engineer for ground support equipment.

ROBERT A. WAGNER has been appointed manager of the helicopter engineering department of Hughes Tool Co.'s Aircraft Division. Previously chief engineer for Hiller Aircraft Corp., Wagner has been associated with the development of helicopters at Hiller, Kellett Aircraft Corp., and McCulloch Corp. He is vice-chairman of SAE Helicopter Committee and a member of SAE Aerospace Craft Activity Committee.

PETER ALTMAN, vice-president of Continental Motors Corp., is head of the newly formed University of Detroit Research Advisory Board, which will review the research work now being done by the University and recommend methods of procedure and of expanding activity.

SAE members who are serving on the board include: **DR. WILLIAM H. HULSWIT**, chairman of division quality committee, Development Division, U. S. Rubber Co.; **ALBERT F. WELCH**, head of electronics, instrumentation department of General Motors Research Laboratories; **K. W. TANTLINGER**, vice-president in charge of engineering and manufacturing, Fruehauf Trailer Co.; **MERRILL A. HAYDEN**, vice-president and general manager, Machinery Hydraulic Division, Vickers, Inc.; **BERNARD J. MELDRUM**, special assistant to general manager, Missile Division, Chrysler Corp.; and, **GEORGE A. DELANEY**, retired chief engineer, Pontiac Motor Division, General Motors Corp.

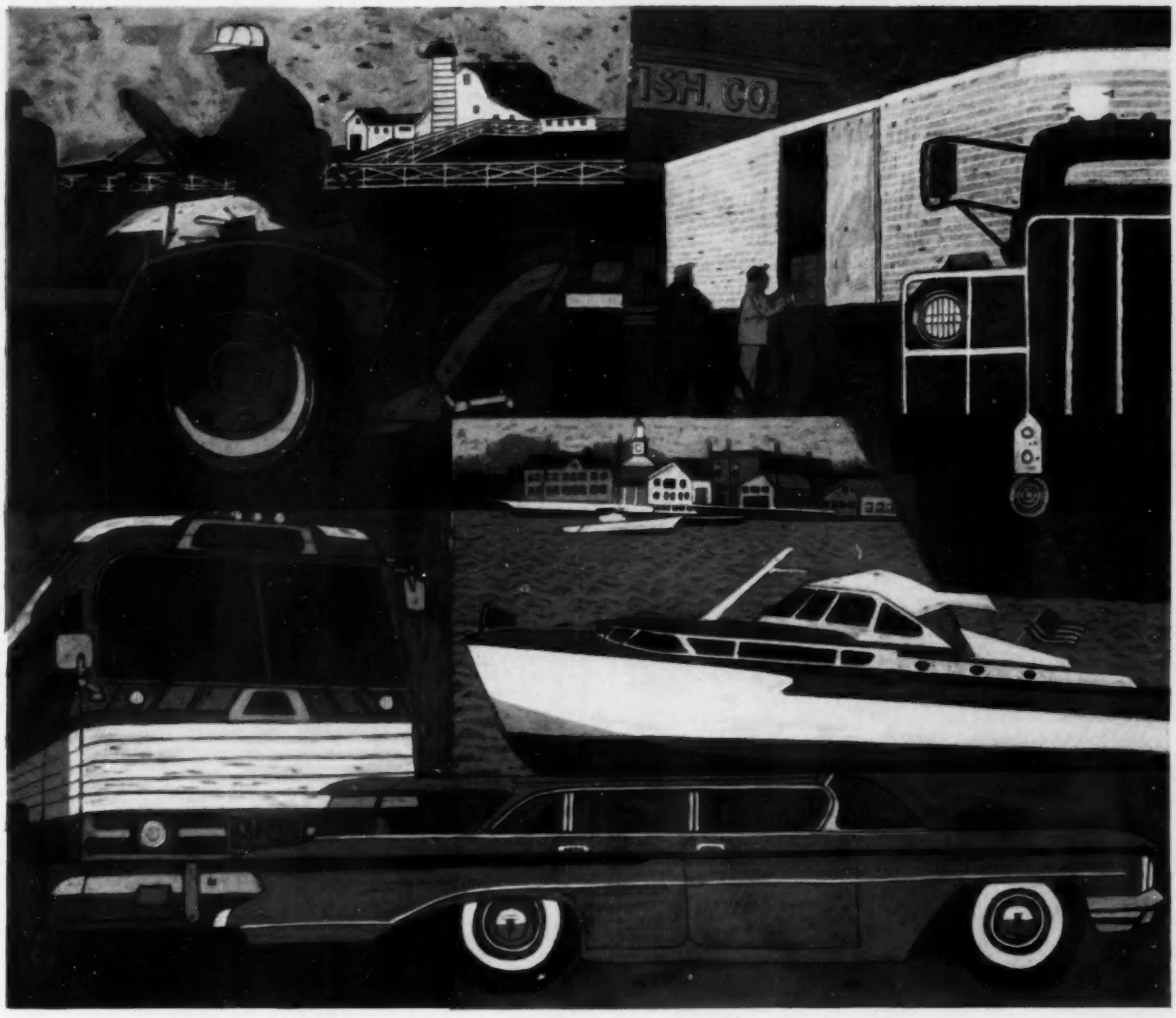
ELLIOTT A. JOHNSON is now owner and manager of E. A. Johnson Co. in Portland, Oreg. In this capacity he operates as a warehouse distributor for three factories selling to the automobile, truck, and industrial wholesale trade.

Previously he engaged in a wholesale parts store, C. & J. Parts Service in Billings, Mont.

HENRY FORD II, president of Ford Motor Co., and **ERNEST R. BREECH**, chairman of the board at Ford Motor Co., served on a committee sponsoring a dinner in honor of Charles H. Kellstadt, president of Sears, Roebuck & Co., which was held May 25 at the Waldorf-Astoria, N. Y. for the benefit of the National Conference of Christians and Jews.

ERIC R. HILBORN has become project engineer for Chrysler Corp. of Canada, Ltd. He was formerly product engineer for Thompson Products, Ltd.

continued on p. 116



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If you want to know more about this new AC pressure switch or have problems in the field of pressure monitoring, get in touch with the nearest AC office. AC sales engineers and pressure switch specialists are as close at hand as your post office, telegraph office or telephone.

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SAE Members

continued from p. 114

STEPHEN C. DaCOSTA has joined the editorial staff of Car Life magazine as technical editor. Previously he was New York editor for Motor Trend.

CHARLES M. CHODASH is now a mechanical engineer for General Electric Co.'s large steam turbine department in Schnectady, N. Y. Formerly he served their distribution transformer department in Pittsfield, Mass. as mechanical engineer.

J. V. TIERNEY, JR. has been appointed to the newly created position of manager of quality assurance for Battery Division of Globe-Union, Inc. Formerly he was supervisor of the electrical unit of body quality section for Ford Motor Co.

BENJAMIN T. HILL, JR., formerly sales representative, is now assistant to vice president in charge of sales for Allegheny Ludlum Steel Corp.

GORDON M. PFEIFFER, previously assistant zone manager, is now zone manager for Chrysler Corp. of Canada, Ltd.

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LENNARD BROWN, previously accessory design engineer at Cincinnati, is now design engineer at Erie, Pa. for General Electric Co. This is the first of three assignments Brown will have in General Electric's Locomotive, Car and Equipment Division. The assignments are designed to acquaint him with the locomotive field and the remaining two will be in the Control Design and Motor Engineering Sections.

EMMET C. MOYNIHAN, JR. has become area product engineer in Detroit for Chevrolet Motor Division, General Motors Corp. Previously he was resident product engineer at Buffalo, N. Y. for Chevrolet Motor Division.

W. MARTIN-HURST has joined The Rover Co., Ltd. in Warwickshire, England as executive director of production. Previously he served Teddington Aircraft Controls, Ltd. as managing director.

GEORGE E. STANTON, previously project engineer, is now chief project engineer for aircraft wheel and brakes at Bendix Products Division, Bendix Aviation Corp.

THOMAS E. DUFFY has joined Convair Astronautics as design engineer. Previously he served Chrysler Corp.'s Central Engineering Division as product design engineer.

GEORGE S. ALLIN, JR. has joined Northwest Engineering Co. as assistant chief engineer. Previously he served J. I. Case Co. in a similar capacity.

WALTER R. OPEL has been appointed chief engineer at The Cross Co. He was most recently engineering manager.

FORREST D. GUNDERSON, JR., previously manager of quality control, is now manager of production control for Westinghouse Air Brake Co.

EDWARD E. MALLOY has become service engineer with Chevrolet Motor Division of General Motors Corp. Formerly he served General Motors as contact engineer.

CARL R. PISERCHIA has joined Machlett Laboratories, Inc. as production engineer. Formerly he was manufacturing engineer for Radio Corp. of America.

TOM K. BARTON has become senior test engineer for Mack Trucks, Inc. Previously he was chief test engineer for Curtiss-Wright Corp.

ROLAND J. FERNEKES has joined Lander, Frary & Clark as manager of manufacturing engineering. Previously he was chief product engineer for Midland-Ross Corp.

J. J. SCOTT is now chief development engineer for Bound Brook Oil-Less Bearing Co. Previously he was district sales manager in Detroit.

continued on p. 119

New Eaton Process Cuts Costs of Alloy-Faced Valves

The new Eaton ECONOSEAT process of applying heat resistant and corrosion resistant material to valve faces makes possible a worthwhile reduction in the amount of costly protective alloys required.

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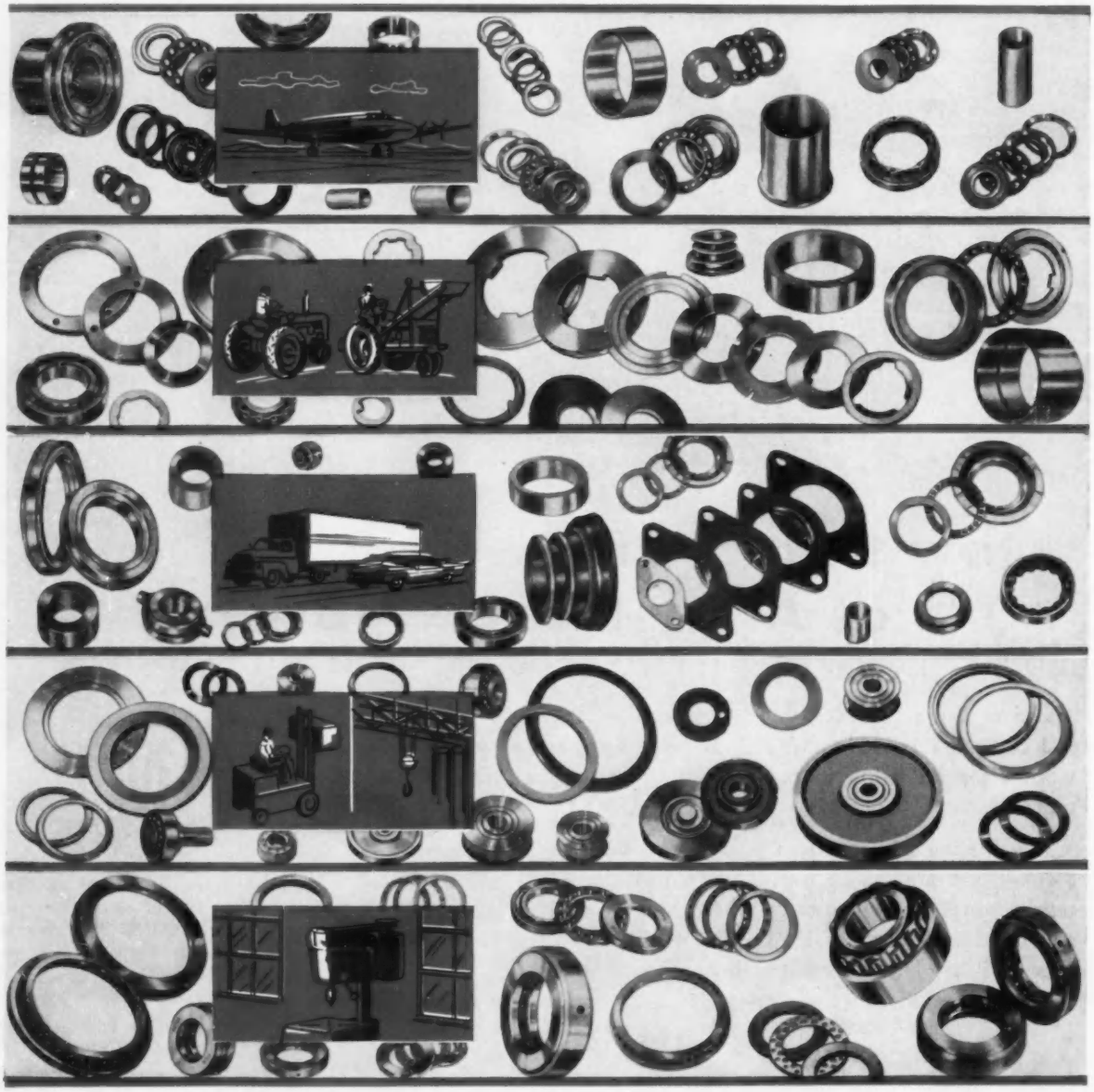

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SAE Members

continued from p. 116

GEORGE E. ROWBOTHAM has joined American Machine & Foundry Co. as standards engineer in Stamford, Conn. Formerly he was standards engineer for Teleflex, Inc. at North Wales, Pa.

JAMES C. PORTER is now head of the mechanical section at the Research and Engineering Department of Hawthorn Finishing Co., New Haven, Mo. Formerly he was section head for Cities Service Research & Development Co.

OLIVER E. RODGERS has become manager of Mechanical Research and Development Division of Scott Paper Co. Formerly he was director of engineering at Curtiss-Wright Corp.'s Utica Division.

CHARLES C. MUGFORD has been appointed district sales engineer at El Segundo, Calif. for the Farr Co. Previously he was special representative for Union Oil Co. of Calif.

Obituaries

JOHN GRABNER . . . (M'23) . . . engineer, Automotive Division, Continental Motors Corp. . . . died February 28 . . . born 1899.

HARRY E. KARST . . . (M'45) . . . air transport consultant . . . died February 12 . . . born 1902.

CORLIS G. KEYES . . . (M'46) . . . chairman of the board of Keyes Supply Co., Ltd, and founder of the company . . . died February 4 . . . born 1880.

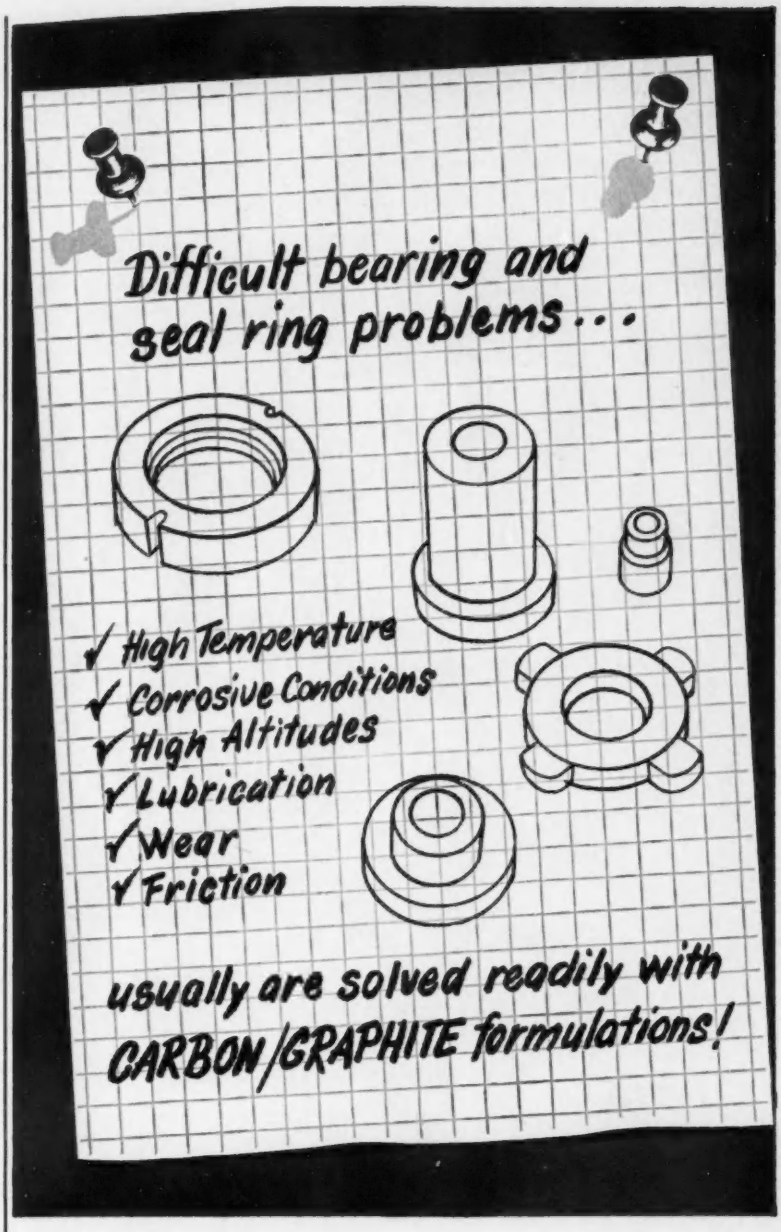
GEORGE JUSTIN MONFORT . . . (M'26) . . . retired . . . died March 19 . . . born 1889 . . . was a past SAE Director.

J. E. PADGETT . . . (M'19) . . . retired vice-president of Solar Aircraft Co. . . . former president of City Planning Commission for San Diego . . . died April 21 . . . born 1896 . . . was a past SAE Director.

ROBERT J. PETERS . . . (M'19) . . . chief metallurgist of Warner Gear Division of Borg-Warner Corp. . . . died February 27 . . . born 1896.

JAMES M. REYNOLDS . . . (M'50) . . . manager of Sheffield Tool & Gauge of Canada, Ltd. . . . died April 26 . . . born 1924.

ALBERT WHITELAW . . . (M'48) . . . retired executive of Manhattan Rubber Division of Raybestos-Manhattan, Inc. . . . died April 24 . . . born 1899.



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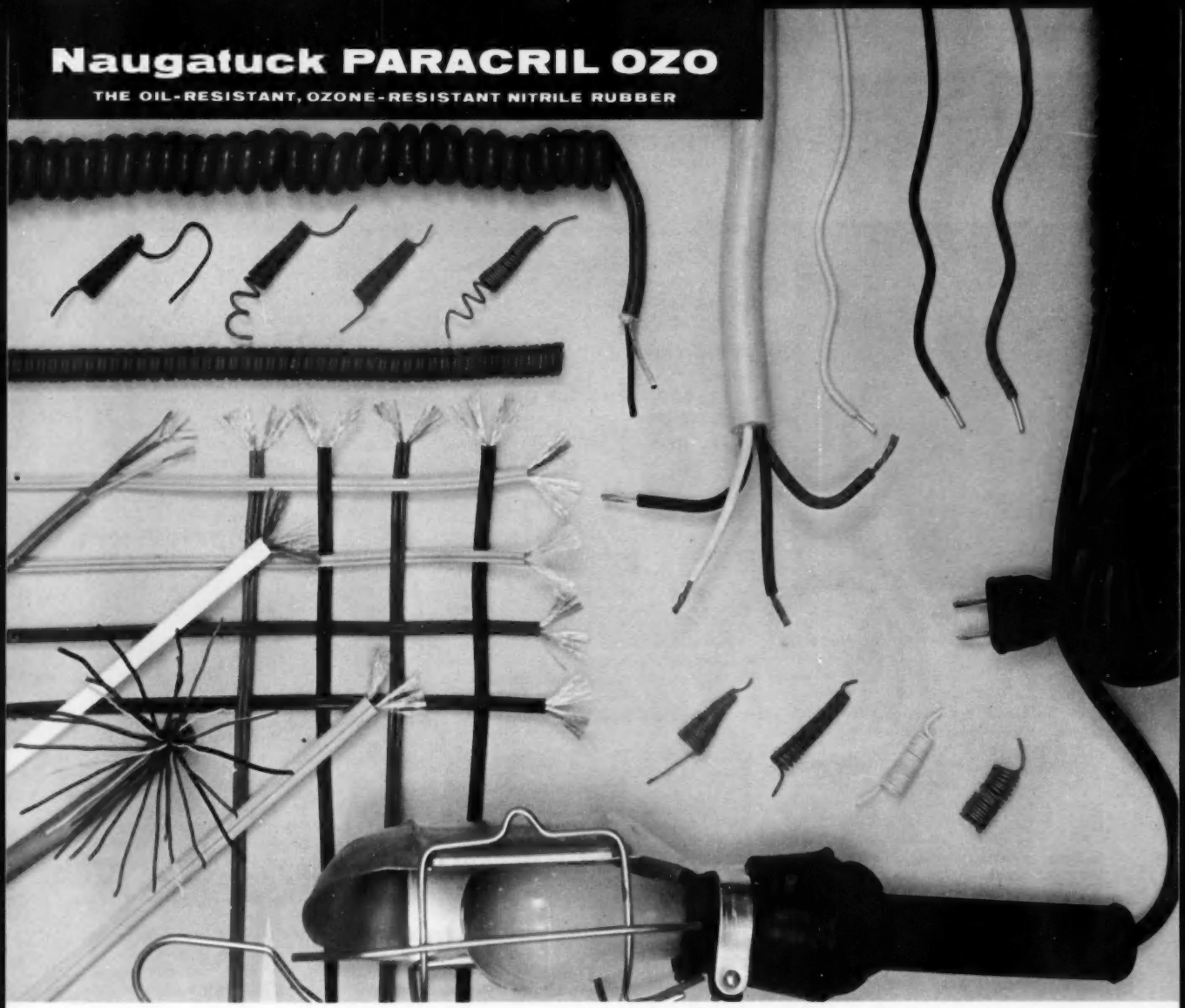

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THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING

THE UNEARTHLY USE OF GLASS

Some day the stellar equivalent of an archeologist will ferret his way through space, collecting debris from the sundry objects we are thrusting out past the pale of gravitation.

That man is going to find a lot of glass.

Next to the metals, glass is *the* basic material for space work. Big claim? Big fact.

You can blast glass out at the stars, shine the sun at it full open, slide it into the cold void of the earth's shadow, plummet it back into the searing atmosphere, recover it from the bobbing waves. And, all the time, glass will hold to its integrity, its properties, its dimensions.

You can design glass *into* a piece of space hardware; you can only know the beauty of this if you have had to design *around* some other material that has interesting properties but is hard to work.

Glass has hardly any design limitations. We can mold it, blow it, fuse it, press and roll it, etch it, temper it, or try any of a dozen other controlled techniques to meet exactly the shape you want, exactly the size you want, exactly the exactness you want.

We have some 60,000 glass formulae to select from, so matching your specs on properties is a snap.

We have combinations of glasses that transmit or attenuate all of the visible light spectrum and most of the infrared and ultraviolet as well.

We can take a mass of glass yards thick and make it as transparent as the objective lens on a microscope, as surface perfect as the facet on a ten-carat diamond.

Big claims? Big facts. Radomes, windows for space capsules, giant mirrors for balloon-floated telescopes, electronic components, macro and micro in size . . . these are just a few of the things you can do with glass . . . and, with all that, you haven't begun to tap the possibilities of glass in space.

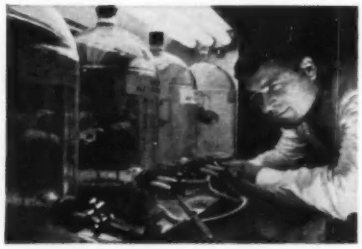
We have two brochures that tell about these properties and design potentials: *This Is Glass* treats of the material itself. IZ-1 discusses the applications. Check the coupon for copies.

WE'LL GROW RED ROSES IN JUNE, JUST YOU AND I UP ON THE MOON

It goes without saying that you cannot grow terrestrial plants in a 10^{-12} mm Hg atmosphere . . . but just how high does the pressure have to be to bring a plant to maturation? What about the effects of a lower gravity? What sort and how much light will you need to make a seedling stir? How about temperature?

Republic Aviation is engaged in some research of this sort, which will form a sort of almanac for the lunar farmer.

We come into the picture with a vacuum-tight greenhouse, often referred to as a PYREX brand bell jar. Besides serving as the perfect lunar greenhouse, it recommends itself on a weight basis.



You might remember this "Moon Garden" if the time comes when you want an environment you can play with and observe. Many are the people using our bell jars for high vacuum and high pressure work, for the creation of an inert gas atmosphere; in short, for any work where you want to free yourself from the deficiencies of the terrestrial atmosphere.

HOW TO SEEK OUT AND HIT A MELTING ICE CREAM CONE IN THE MIDDLE OF ALASKA

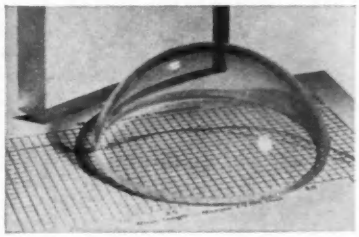
We make the glass that goes into the domes that transmit the infrared waves that activate the cunning minds of the heat-seeking missiles that go pow.

Today we make a better IR transmitting glass than ever before. We call it Code 9752.

A 2mm thickness of this glass will transmit 77% at the 4.0 micron wave length and 38% at 5.5 microns. Not bad.

At 600°C there is no transmission loss whatsoever at 4.0 microns, only 13% at the 5.5 micron wave length.

Our research people say the glass has



"good" electrical properties, "excellent" weathering characteristics. Our research people are known as conservatives.

In a durability test, we found that there was no appreciable transmittance loss in 21 days at 95% RH with temperature cycling from 25°C to 65°C twice a day.

Using standard techniques, we can mass produce this glass in a variety of hollow shapes and give it an optical finish. We can press 7″ domes automatically and make larger sizes to order. Flat pieces, 12″ square and ½″ thick, are being used in the instrumentation field for such devices as Schmidt corrector plates.

The coupon offers a bulletin on this and two other Corning IR transmitting glasses.

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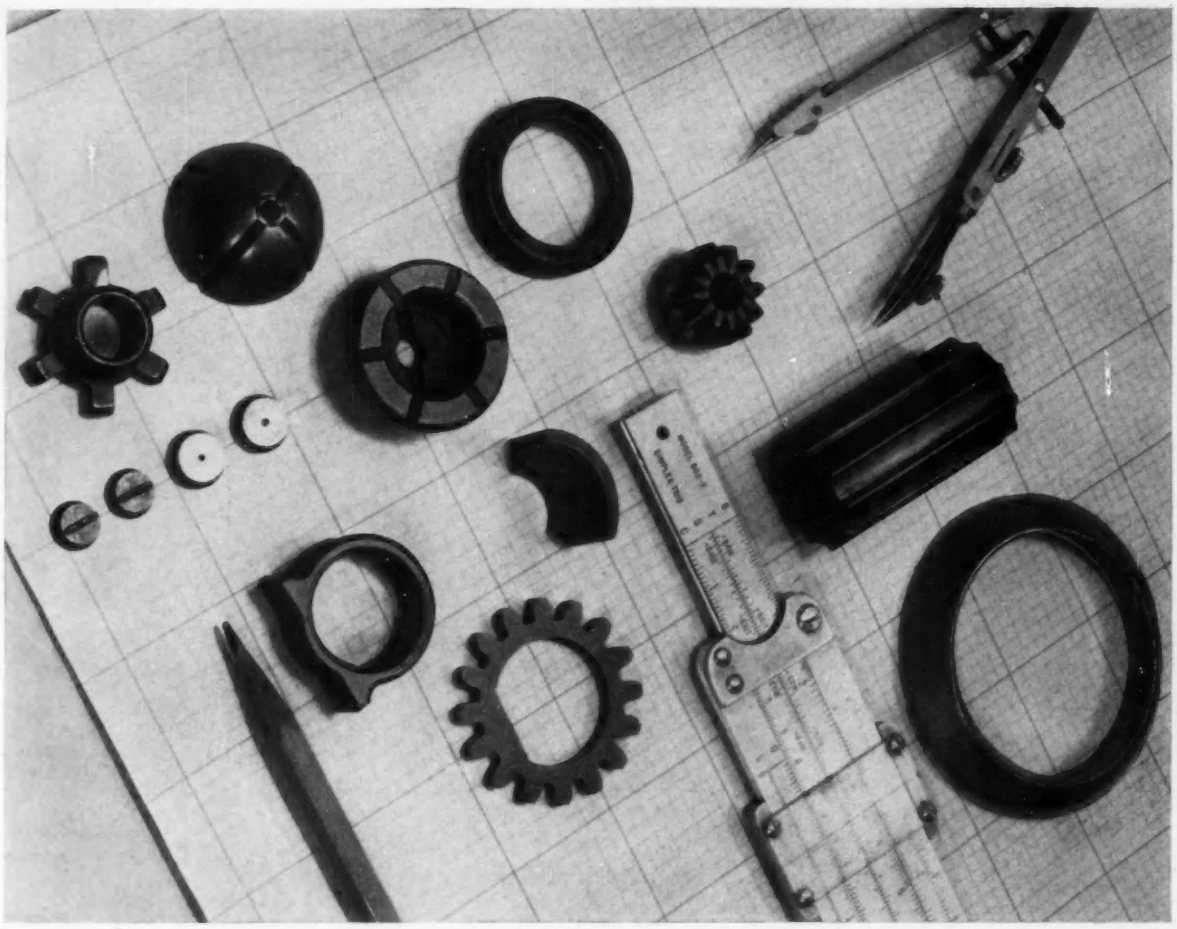

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It's true for accessory drives—for windows, fans, seats and the like. It's true for timing chains, the field which Morse has *always* led. And, now it can be true even for turbine engines.

Morse's business is the *complete* power train—basic drives, speed reducers, couplings and clutches. It offers each of these in a variety of types and sizes no other single source can match. It offers them singly or in combination. Literally, Morse can help you design—and then *supply*—systems that deliver power to everything from a car window to an oil rig!

So let your imagination go. Let the Morse man help you find a better way. Call him, or write: Morse Chain Company, Dept. 12-60, Ithaca, N.Y. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ontario.

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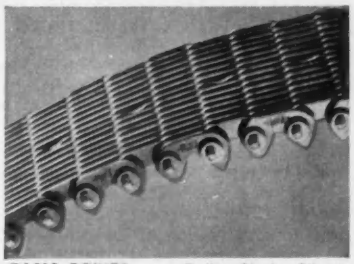

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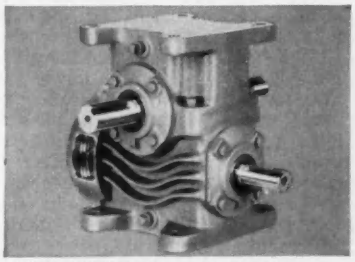

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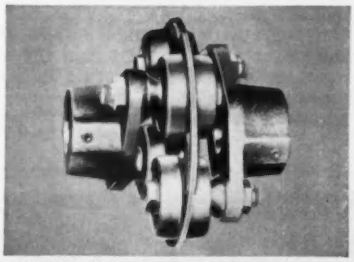
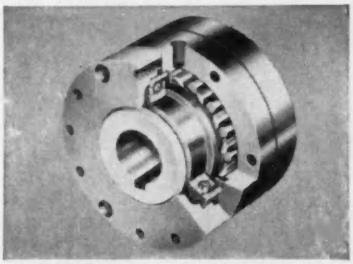


COUPLINGS . . . Flexible Roller and Silent Chain, Morflex, single and double; and Morflex Radial and Marine.



CLUTCHES . . . Morse Cam (Over-Running, Indexing, Back Stopping), Pullmore, Over-Center, Torque Limiter, and Centrifugal.

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YOUR
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continued from p. 96

at an annual cost of about 1% of the cost of the car.

The average motorist thinks short trips and "engine never gets really hot" represent easy service, whereas it is severe service from the standpoint of wear. For this reason, a time basis would seem to be more foolproof than a mileage basis. The median driver covers 625 miles per month with a median trip length of 3.8 miles. This represents 165 trips a month, or between 5 and 6 trips per day. The typical driver's oil will reach 0.5 base number in about 900 miles and under unfavorable conditions in about 625 miles, or the median monthly mileage.

If oil changes were scheduled on a monthly basis, it would mean short mileage drain periods to the short trip driver, while permitting a 2000-mile drain period to the extended trip driver. For the commuting driver who drives to and from the train five days a week and makes only short trips on the week end (about 400 miles a month), the recommended drain period would probably be every two months.

If the objective is to establish an oil drain period that will protect substantially all drivers, then the recommended mileage would have to be 700. However, used oil samples show that the longer the trips, the longer the base number lasts and, accordingly, 2000 miles is not an unreasonable period for favorable driving conditions.

Factors Making for

OPERATING COSTS

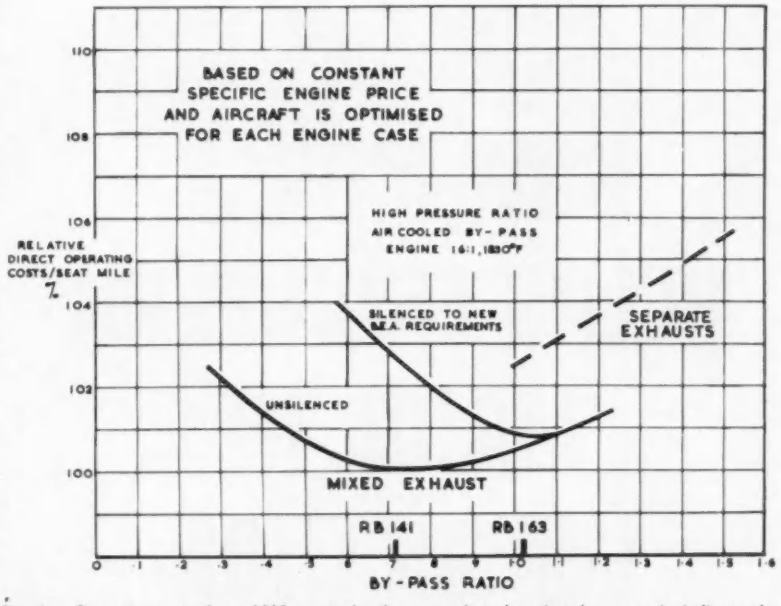
BASED ON CONSTANT SPECIFIC ENGINE PRICE AND AIRCRAFT IS OPTIMISED FOR EACH ENGINE CASE
HIGH PRESSURE RATIO AIR COOLED BY-PASS ENGINE 16:1, 1830°F
RELATIVE DIRECT OPERATING COSTS/SEAT MILE %
SILENCED TO NEW B.E.A. REQUIREMENTS
SEPARATE EXHAUSTS
UNSILENCED
MIXED EXHAUST
RB 141
RB 163
110
108
106
104
102
100
0 ·1 ·2 ·3 ·4 ·5 ·6 ·7 ·8 ·9 1·0 1·1 1·2 1·3 1·4 1·5 1·6
BY-PASS RATIO

Fig. 1 — Operating costs for a 1000-nautical-mile stage plotted against bypass ratio indicate the optimum ratio to lie in the range 0.7–1.05, depending upon noise requirements. The advantage of mixed exhaust is also shown.

for Quality in QUANTITY

LARGEST PRODUCER OF SMALL

Bypass Engine Efficiency

Based on paper by

A. A. LOMBARD, Rolls Royce, Ltd.

and D. GERDAN, Allison Division, GMC

CORRECT bypass ratio, mixed exhaust, and high turbine inlet temperatures are three key factors for efficient airline engines.

A plot of direct operating costs against bypass ratio for a 1000-nautical mile stage is shown in Fig. 1. The optimum ratio lies between 0.7 and 1.05, depending on the noise requirement. BEA have specified for the DeHavilland DH.121 a noise level, at a point on the ground 2.5 miles from the start of take-off, that is 6 db quieter than both the Comet 4 and Viscount aircraft, both of which have established themselves as acceptable in service. It is this value of noise level that has been assumed here.

The curves in Fig. 1 indicate that the bypass engine offers a distinct advantage over the pure jet, and that the bypass ratio should not be outside the range of 0.7–1.1, the actual value being determined by noise requirement.

Mixed vs. Separate Exhaust

The curves also show the advantage of mixed exhaust. It would seem that there should be only one efflux from the engine (also that the whole of the air should be taken in in a common intake). All Rolls-Royce bypass engines have a bypass duct carrying the bypass air to a point rear of the turbine and directing it into the main jet pipe. If the mixing is done efficiently, it is possible to get an improvement in performance due to the increase in propulsive efficiency of a substantially constant efflux velocity compared with having hot and cold streams at different velocities. To mix with low losses requires low velocities and the total pressure of the two streams must be sensibly equal. Rig tests indicate that in actual practice the losses in the mixer can be reduced to a level giving an overall improvement of just over 2%.

Value of High Temperature

All experience and theoretical studies on bypass engines confirm the advantages to be gained by operating at high turbine inlet temperatures. Fig. 2 illustrates the effect of turbine inlet temperature and bypass ratio on operating economics. Note that increasing the temperature is progressively beneficial as bypass ratio is increased. With a pure jet engine there is virtually no advantage to be had from high inlet temperatures, assuming the engine is at the stage where it can be sized to suit the application. Naturally, this does not apply where an engine is undersized in power relative to the development growth of the aircraft.

To order Paper No. 172C . . . from which material for this article was drawn, see p. 6.

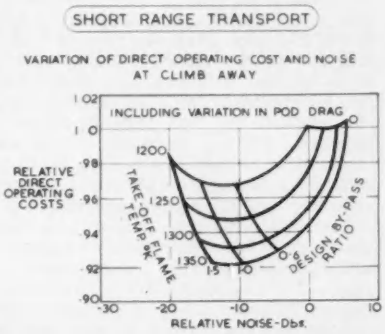

Fig. 2 — Increasing turbine inlet temperature is progressively more beneficial to operating economics as bypass ratio is increased.

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RINGS IN THE INDUSTRY

Shaft Power Turbine Coming Engine for Navy

Based on paper by

COM. A. L. RASMUSSEN, USN

TURBOPROP and turboshaft engines seem destined to become the leading powerplants for naval aviation.

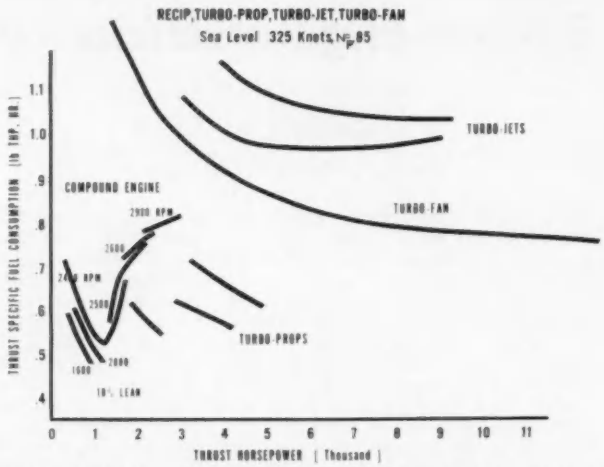
The Navy's most important mission is antisubmarine warfare, requiring aircraft with long range, loiter capability, endurance, large payload, high reliability, and a reasonable amount of crew comfort. Until now, aircraft with reciprocating engines have done this job most effectively, but limitations in power and "dash" speed capability have made this type of engine almost obsolete for antisubmarine warfare. The turbojet and turbofan cannot do the job satisfactorily because of high fuel consumption and poor take-off characteristics. The turboprop, though not so economical as the reciprocating engine, provides a logical compromise between economy and mission requirements.

The shaft-turbine is also a better match than the reciprocating engine in helicopters because its best efficiency is realized at a relatively high percentage power. Greater power in a smaller and lighter package, as well as installation adaptability are additional assets.

Studies have shown the shaft-turbine to be a logical choice for VTOL and STOL aircraft because it has ⅓ the specific weight of the reciprocating engine and a high static thrust capability in combination with propellers or rotors. Such thrust cannot be realized in a comparable jet or fan engine with any degree of fuel economy.

Finally, the shaft-turbine is desirable because it permits standardization to jet fuels aboard ship and avoids the fire hazard of gasoline.

Fig. 1 shows the sea-level performance of typical reciprocating, and high-pressure-ratio turboprop, turbofan, and turbojet engines. The performance of propellered engines is corrected for a propeller efficiency of 85%. Static conditions were avoided since actual operation at this condition is limited.



The same comparison for 15,000-ft altitude is shown in Fig. 2. Fig. 3 presents a "canned" antisubmarine mission using the assumptions and conditions as shown. Modern engines were selected to give essentially the same amount of take-off thrust to the aircraft using each type of engine. All aircraft have four engines except the one using turboprops, which has two.

To Order Paper No. 170A . . . from which material for this article was drawn, see p. 6.

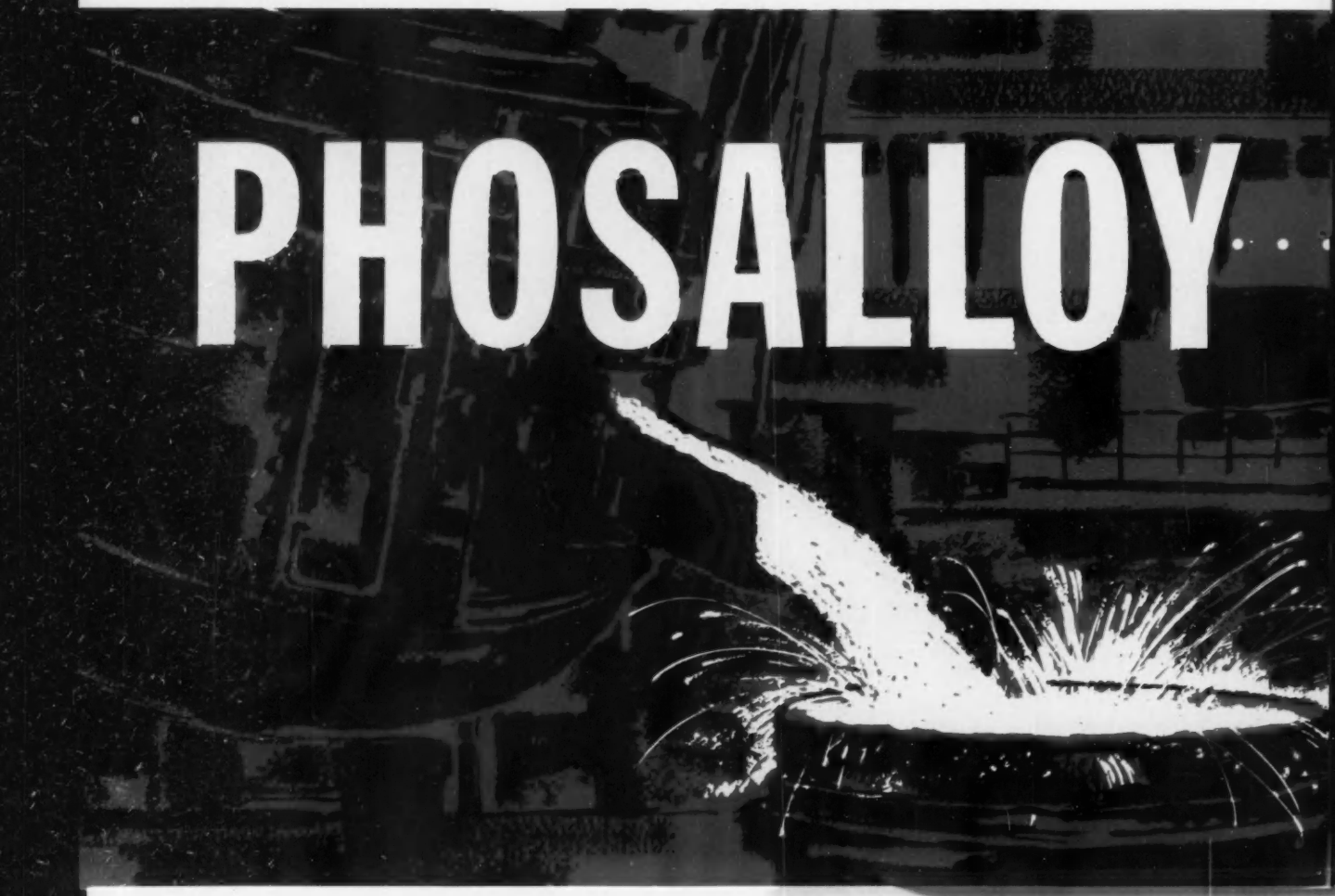
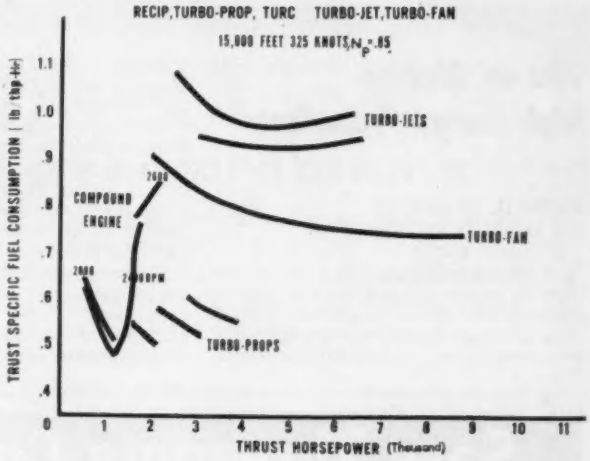


Fig. 1 — Specification performance comparison for engines operating at sea level. The compound engine shows a highly desirable low fuel consumption at part power. Turboprops compare favorably down to about 60% of maximum power. Fan and jet engines show much greater total power capacity but also much greater fuel consumption.

Fig. 2 — At 15,000-ft altitude, fuel consumption of the reciprocating engine shows little change, while that of the turbines improves. At higher speeds and altitudes, turbines would show much improvement over the reciprocating engine.



—ASSUMED AIRCRAFT CHARACTERISTICS—

TAKE OFF GROSS WEIGHT	95,000 LBS.
STRUCTURAL WEIGHT	21,280 LBS.
EQUIPMENT WEIGHT	10,735 LBS.
CRUISE L/D RATIO	15
TAKE OFF THRUST	~CONSTANT
ENGINES	TURBO-COMPOUND, TURBO-PROP, TURBO-FAN, TURBO-JET
CRUISE SPEED	300 KNOTS

Fig. 3 — This canned version of an antisubmarine mission dramatizes the advantages of the turboprop engine at intermediate speeds and altitudes and explains why it is most suitable for antisubmarine missions and likely to replace the reciprocating engine.

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ST. LOUIS • TORONTO

Tips on Making High Energy Propellants

Based on paper by

JOHN D. CLARK
U. S. Naval Air Rocket Test Station

TO GET specific impulse — the thrust of a rocket divided by the rate of consumption of the propellants — pick your exhaust products, not primarily your propellant. Look at what's coming out of the nozzle before worrying about what you're going to put in at the other end.

Specific impulse can be had in gratifying quantities from a system which produces large amounts of hydrogen, plus a highly exothermic exhaust gas to warm it up, preferably one with a good R/C_p of its own. HF is the ideal, but even H_2O is not to be despised.

There are certain things to avoid because they won't make a high energy propellant. Solid exhaust products, particularly carbon, is one. Carbon contributes no energy and with an R/C_p of zero it isn't going to help in the conversion of any energy from anywhere else. It just goes along for the ride and drags its feet. Incidentally, if you are burning a hydrocarbon, say, with fluorine, add enough oxygen to the system to take the carbon to CO. The oxygen and the fluorine arrange a Jack Spratt sort of marriage, the fluorine going after the hydrogen and the oxygen going after the carbon, so that you get HF plus CO for exhaust gases, a high energy release and a good R/C_p, and a performance that makes everybody happy.

A second thing to avoid is complicated (polyatomic) exhaust products. Their high energy release is generally overbalanced by their low R/C_p, so that no matter how exotic or expensive the propellants that produce them may be, the results are generally not worth the trouble.

To order Paper No. 177A . . . from which material for this article was drawn, see p. 6.

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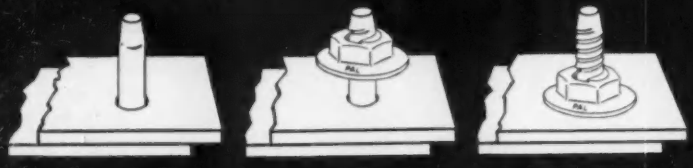

WASHER TYPE—STYLE SD

One-piece self-threading nut performs functions of ordinary nut, lockwasher and flat washer. Resilient washer base distributes tensile force, avoids dimpling of sheet metal or damage to fragile parts. Available with large or small base diameters; also with bonded-in plastisol compound to seal out water and dirt. Stud sizes: 1/8", 5/32", 3/16" and 1/4" dia.

Low in price—fast assembly—vibration-proof grip.

Spring-tempered steel PALNUT Self-threading Nuts apply like any ordinary nut with standard tools or high-speed PALNUT magnetized wrenches. Assemble perfectly, even on off-angle studs, in confined space, against curved surfaces. Hold tight, seated or unseated. May be removed and re-used on same studs. Use on any malleable material.

REGULAR TYPE—STYLE SR

For assemblies where space is limited. Uses shorter studs, less seating area. Internal wrenches may be used. Stud sizes: 1/8", 5/32" and 3/16" dia.

ACORN TYPE—STYLE SC

Decorative nut covers stud ends in exposed areas to protect against scratching, snagging or tearing. Stud sizes: 1/8", 5/32" and 3/16" dia.

Write for Bulletin 585-A and Free Samples, stating style, size and application.

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Engineering Safety Into Highway Design

Based on talk by

JOHN C. MACKIE
Commissioner, Michigan State Highway Department

(Presented before SAE Mid-Michigan Section)

STUDIES of the accident rate on 175 miles of new expressways and on the roads they replaced, show a reduction of 77% in number of accidents and 76% in number of injuries, for comparable periods of one year. These reductions were gained even though many of the new expressways carried a much larger volume of traffic than the old roads they replaced.

The studies also showed the fatality rate on four-lane, divided highways without access control to be double that on controlled access routes, while the accident rate was nearly three times as great. On some of the expressways without access control the accident and fatality experience was actually worse than on some two-lane roads.

Although four-lane, divided expressways without access control are capable of carrying a much larger volume of traffic than two-lane roads, they expose the motorist to the same accident hazards, at a higher average rate of speed, while giving him a false sense of security. Consequently, only in urban areas or on very rare occasions will the State of Michigan continue to build four-lane, divided highways without acquiring right of way for access control.

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for tough valve gear problems

When you're facing difficult problems involving valve gear, the men to see are Chicago's tappet engineers. For, in 25 years of specialization on valve train parts, we have encountered and solved many problems similar to yours.

Applications, such as those illustrated, are typical examples . . . and the operational records established by Chicago tappets of all types in more than 25,000,000 engines are the best testimonial to their success in meeting the toughest industry requirements.

Even when your engine does not present unique requirements in valve gear design, checking with Chicago can often assure a performance bonus. Chicago's hydraulic tappets, for example, assure longer trouble-free life, reduced starting noise, and quieter operation.

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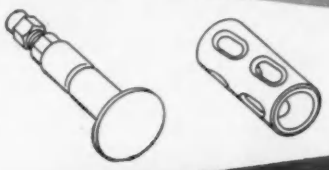
Car, truck, tractor, diesel . . . aircraft, outboard, power mower, or industrial . . . whatever your type of engine, big or small . . . it will pay you to consult Chicago's development engineers *while you are still in the preliminary design stages.*



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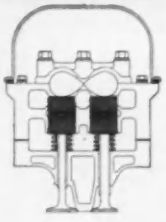
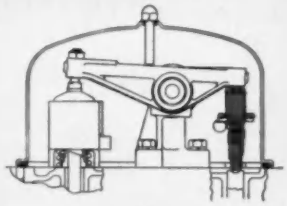
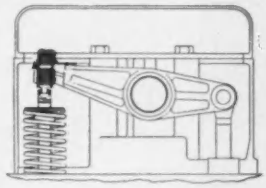
Hydraulic and Mechanical Tappets (Barrel or Mushroom Type) of Alloy Steel, Hardened Alloy Cast Iron, Chilled Iron, or Alloy Chilled Iron • Push Rods • Adjusting Screws



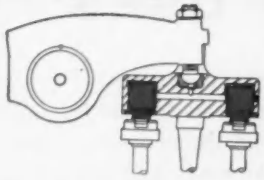
Hydraulic Inverted Cup Type Unit



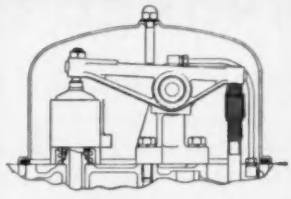
Push Rod Type with Compression Release Application



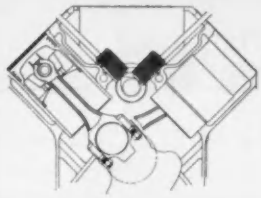
Threaded Type Rocker Arm Unit



Dual Valve T-Bridge Hydraulic Application



Hydraulic Unit on End of Push Rod



V-8 Automotive Hydraulic Tappet Application

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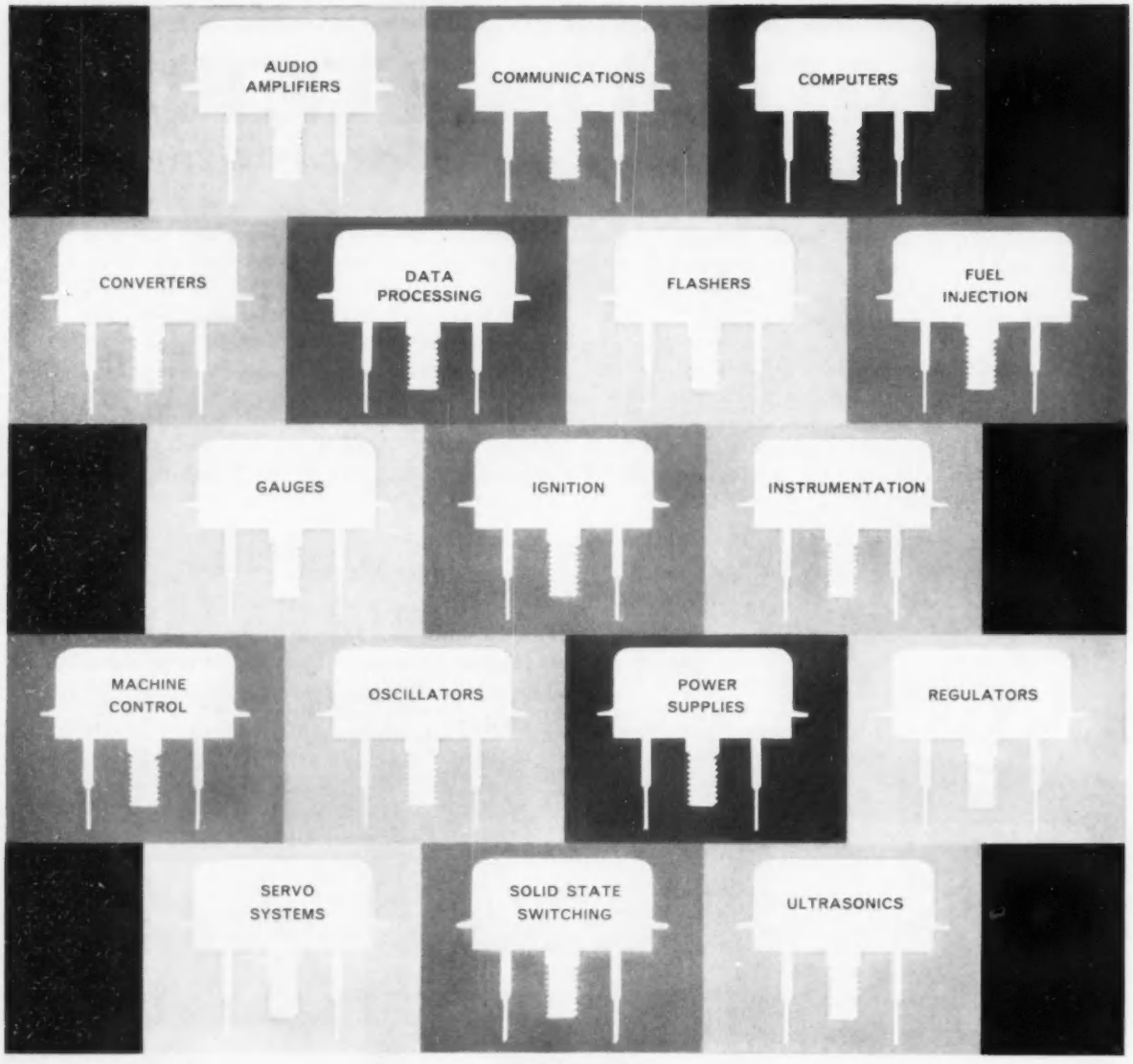

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Multiwheeled Vehicles Pass the Dream Stage

Based on talk by

TOM EMERSON
R. G. LeTourneau, Inc.

(Presented before SAE British Columbia Section)

VEHICLES with 50 wheels all receiving their driving force from a central powerplant are no longer dreams. The LeTourneau off-shore drilling platform provides an example and demonstrates the flexibility of the system.

The largest of these triangular-shaped platforms weighs in the neighborhood of 8,000,000 lb, yet after being towed into position this huge machine lowers its three legs to the ocean bottom and raises itself above the water at the rate of 1 fpm. The open truss design of the legs offers little resistance to wind and wave action and the platform raises itself above the level of anticipated heavy-weather wave heights. After the well has been completed, the machine lowers itself back into the water, using the braking characteristics of the motors.

In a still newer development, a 16,000-ft-ton capacity crane is mounted on one of the smaller off-shore platforms. When the operating site is reached the legs are lowered to the sea bottom, the machine lifts itself approximately 10 ft above the water, electric pumps are started and about 750,000 lb of water are pumped into the ballast tanks. The water, plus the weight of the barge, causes the feet of the platform to penetrate deeply into the ocean bottom. Then the water is pumped overboard, the machine rises to its desired working height, and the crane can pick up its load without danger of further penetration. If the weight of the boom is ignored, this crane is equivalent to one having a boom 3 miles long and lifting a 1-ton load.

Spare Space Pilot Useless Information!

Based on paper by

C. J. HECKER
Sperry Gyroscope Co.

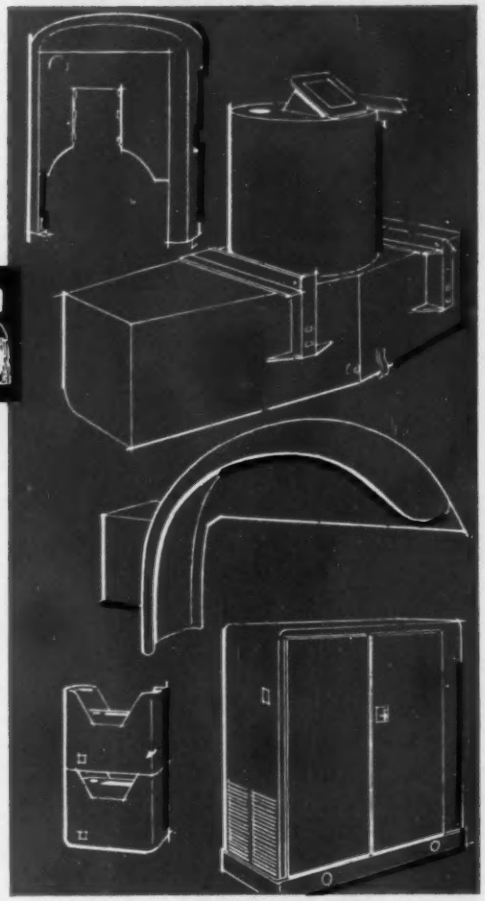
THE ENVIRONMENT will limit the space pilot's ability to manipulate controls, so there is no point in displaying information he can do nothing about. It will only make him uneasy. Display should be limited in number and complexity to minimize scanning and interpretation, and be similar to that used for "inner" space aircraft.

A space mission will have three phases — escape, exo-atmospheric, and recovery. Escape involves take-off and exit. Tasks during this phase must be performed by highly reliable computers feeding programmed information into an automatic control system. The pilot will monitor the progress of the mission and correct deviations from the desired program by such simple control motions as pushing a button or flipping a switch to bring corrective forces into operation.

Vertical orientation, velocity along the path, and altitude will determine successful exit, and for these conventional instrumentation will suffice. Once the exit phase has placed the vehicle in position for successful orbit-

continued on p. 135

Know-How for Hire



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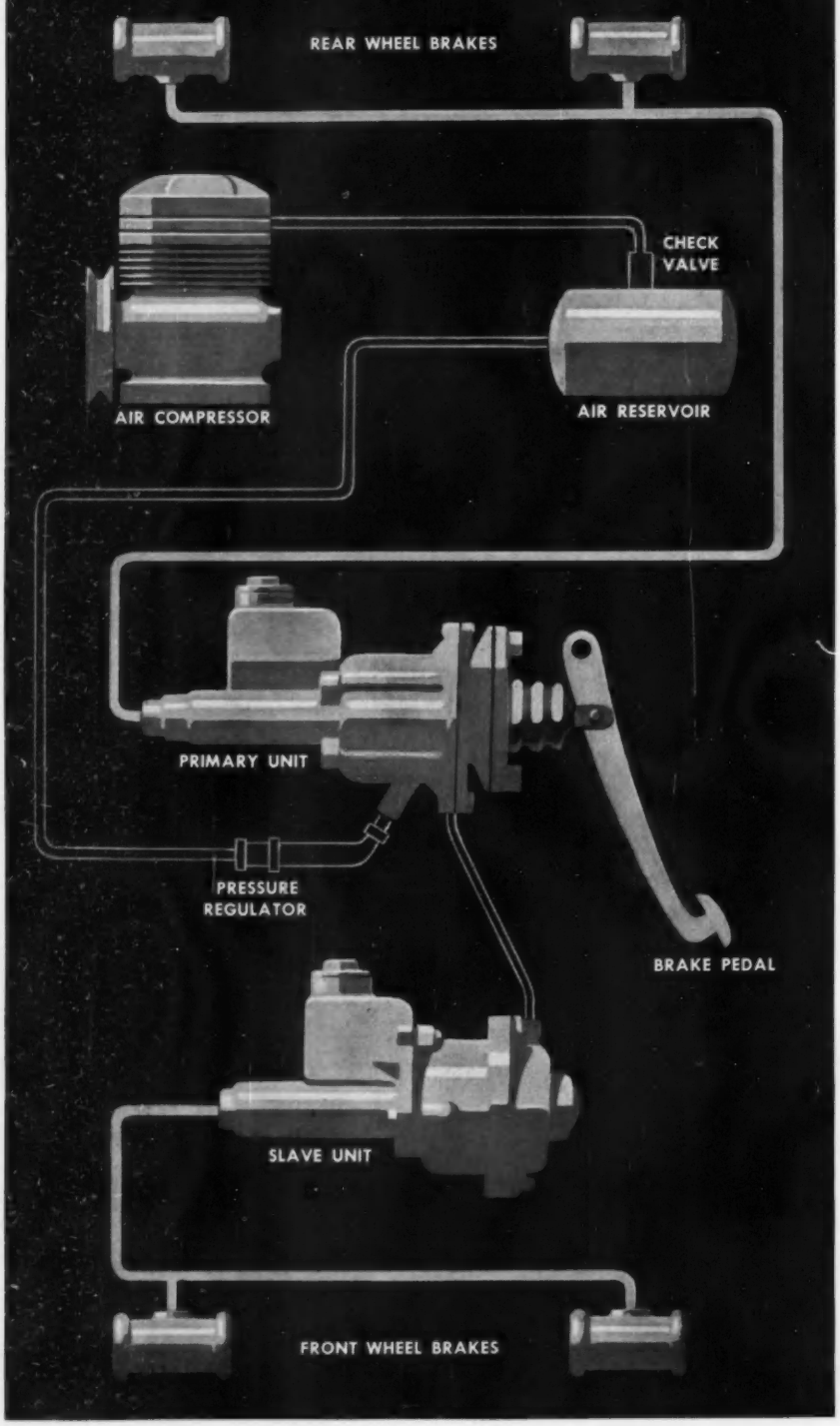

this new concept consists of two independent air-actuated hydraulic systems, both of which are operated by the master unit.

1 If rear hydraulic line or wheel cylinder fails—you still have full front brakes with their own power assist!

2 If front hydraulic line or wheel cylinder fails—you still have full rear brakes with their own power assist!

3 If air supply should fail—you still have direct mechanical actuation of full rear brakes!

Write for "Three-Way Safety Brake System" brochure. Kelsey-Hayes Company, Detroit 32, Michigan.

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continued from p. 133

ing, the problem will be one of navigation. Travel during this phase will be under automatic control, the pilot monitoring the performance.

During this phase of flight, the pilot will be expected to make radio link reports of scientific data, taken from auxiliary measuring equipment, and of visible phenomena taking place outside the vehicle. He'll be pressed for time and for this reason indications of required control must be obvious and clear, and the means for control kept simple.

The entry stage of the recovery phase is the most critical in the entire flight profile. There will be no more than 20 min in which to:

1. Align the vehicle precisely with the orbital path.
2. Establish the correct nose-up attitude for firing the retro rockets to slow the vehicle.
3. Change the pitch attitude for the correct re-entry angle to within ± ¼ accuracy and start on the re-entry stage. This accuracy is needed to stay within thermal and structural limits of the vehicle.

A three-axis indicator can be used to monitor these maneuvers. Then, once the vehicle is within the atmosphere, conventional display and sensors can be used for control during the approach and landing phase.

For order Paper No. 173C . . . from which material for this article was drawn, see p. 6.

Metallic Tracers Tried To Clock Lube in Exhaust

Based on paper by

F. R. Bryan, J. C. Neerman, J. E. Hinsch
Ford Motor Co.

TO DETERMINE how much lubricant is coming through in the exhaust of a car or truck engine, Ford has already tried out a new method in principle. It consists of tracing a lubricant additive through the engine and detecting it quantitatively in the exhaust.

In this system, an alkali metal is desirable as the tracer element. It is desirable because the requirements dictated that the tracer element:

- Could not be purely hydrocarbon in nature, since the molecular species derived from the lubricant are not distinguishable from molecular species of a fuel after both have been subjected to combustion.
- Should not be a component of the engine fuel or air.
- Should be detectable in very low concentrations.

Preliminary calculations in arriving at this system indicated that 0.5% by weight of tracer metal in the lubricant should be measured in automotive exhaust by means of flame photometry.

When the oil consumption of an engine is assumed to be about 1 g per min, the tracer would be emitted at the rate of about 0.005 g per min. . . . If it is also assumed that exhaust flow is about 50 cfm, approximately 1700 g of exhaust would be emitted each second.

Concentration of metal in the exhaust stream, therefore, would be around 3 parts per million. Since sodium is known to be detectable to 0.01 part per million in flames when the sample is introduced in the form of aqueous mist, it was reasonable to expect to detect 3 parts per million of sodium in exhaust with some degree of accuracy. Actually, experiments indicate that sodium can be detected in

continued on p. 136

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continued from p. 135

exhaust in concentrations of the order of 1 part in a million.

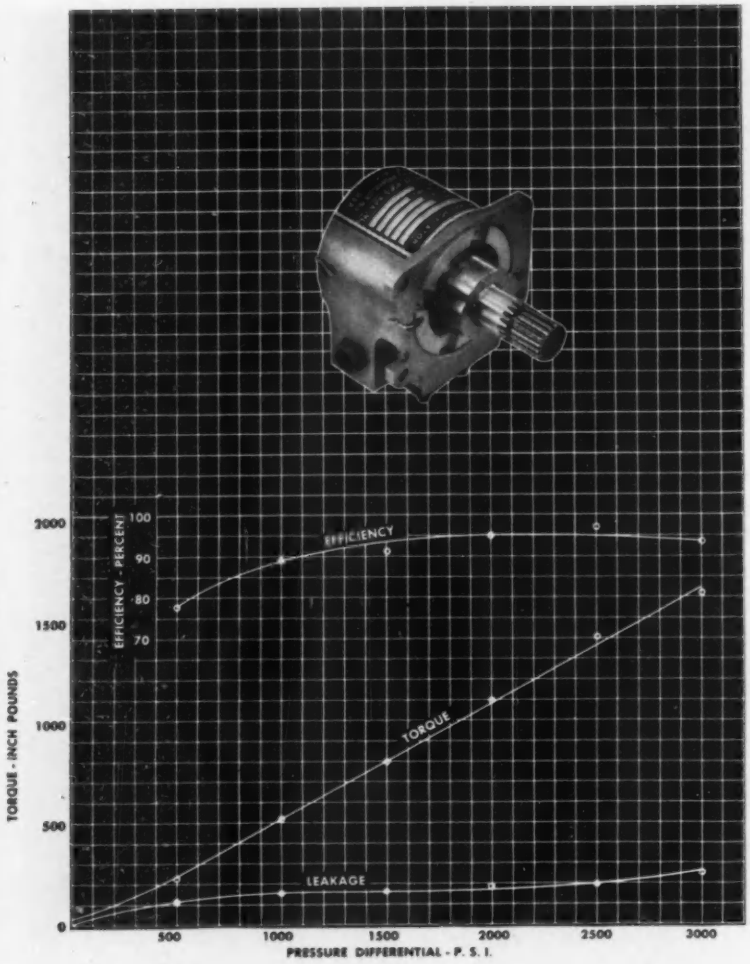
Experience to date indicates, too, that potassium or lithium tracers would be expected to have nearly the same detectabilities as sodium. Rubidium, calcium, and strontium should also be detectable in quantities of a very few parts per million. . . . An optimum additive content in the oil would probably be a compromise between an amount sufficiently large to provide the measuring accuracy required, and an amount small enough to avoid mallubrication of the engine.

In this system, the rate of lubricant loss through the exhaust system can be nearly instantaneously indicated and recorded. In experiments already made, the time lag has been about 2 sec, but no doubt could be reduced to less than 1 sec.

Varied Use Possible

As systems based on this principle are further developed, they could also provide a means of studying short-term oil consumption characteristics as a function of engine operating variables. They might also be used to shorten the time needed to get oil consumption data under any given set of operating conditions. . . . A rapid method of checking oil consumption may also establish the feasibility of 100% inspection of new engines.

To order Paper No. 194C . . . from which material for this article was drawn, see p. 6.



Reliable positioning of airborne radar controlled by new Houdaille Rotary Actuator

At speeds approaching Mach II, airborne radar must be controlled quickly and precisely. That's why Magnavox incorporated this Houdaille hydraulic ROTARY ACTUATOR in the radar unit they supply for the Chance Vought F8U-2N Crusader.

Like all Houdaille ROTARY ACTUATORS, this one is lightweight and operates at 98% efficiency. Direct rotary motion without mechanical conversion provides accurate positioning.

Close coupling of the actuator saves valuable system weight and space. Minimum backlash, low internal leakage and low friction insure a highly responsive unit.

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Value Analysis— Key to Real Profits

VALUE analysis is an organized approach to the removal of cost. It functions to make a product in less time, or less expensive materials, yet make it better and capable of giving as reliable service as the original product. It supplements rather than replaces cost reduction programs.

Value is not inherent in anyone's product. The cost of producing an item does not determine its value. Value is set in the marketplace and that fact is being brought home by the mounting foreign competition. If we are to hold our own in world markets something more must be added than is provided by our traditional know-how and the impetus of new skills. Our sloppy habits of wartime production are still with us and they will not suffice for a dynamic economy.

Making Value Analysis Work

The effectiveness of a value analysis program depends heavily on selecting

continued on p. 141

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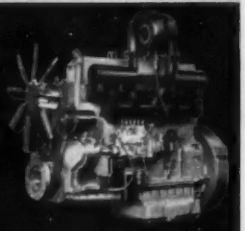
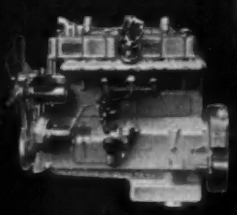
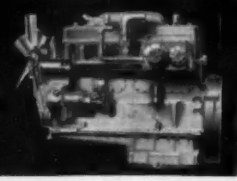
6¼ x6½" bore and stroke, 1197 cu. in. displ., up to 400 hp. at 1800 rpm.



WAUKESHA 145-GZB HIGH OUTPUT GASOLINE ENGINE
5½x5" bore and stroke 817 cu. in. displ., up to 268 hp. at 2400 rpm.



WAUKESHA WAKB BUTANE-PROPANE ENGINE
6¼ x6½" bore and stroke, 1197 cu. in. displ., up to 300 hp. at 1800 rpm.



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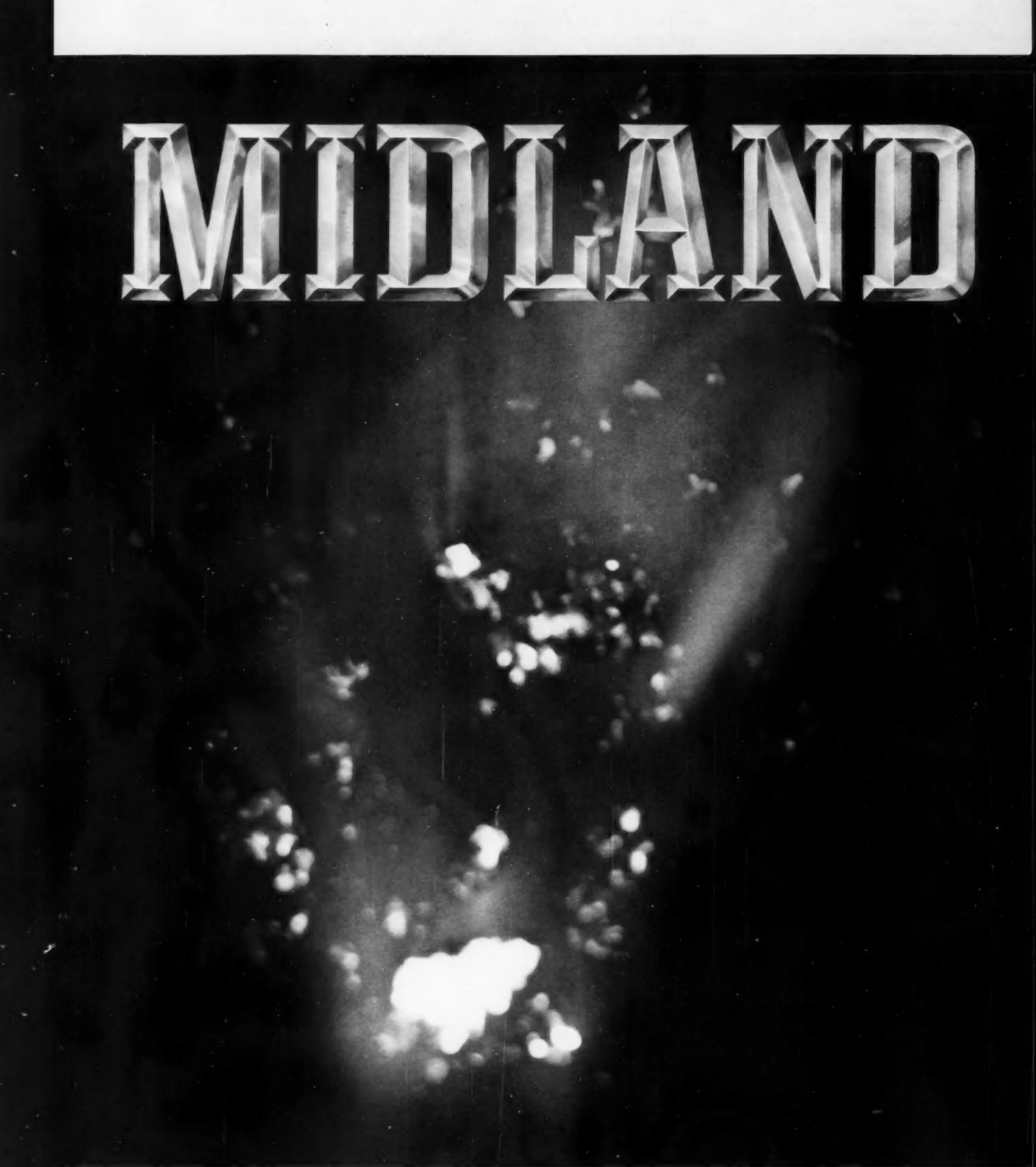

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Headlight and fender were removed, but adjacent parts were not damaged or distorted. Door frame and body frame were not bent, either. In fact, the door did not even need refitting.

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continued from p. 136

the right people to run it. They are, by definition those with nimble minds, open to suggestion, by nature inquisitive and having a background of experience in the areas to be analyzed. The team, small in numbers, works on approved projects without regard to departmental lines, and in some instances reports to a vice-president with the same level of authority as engineering, manufacturing, and sales. Its duties are to break down a product functionally with a view to substituting, changing, deleting, or redesigning. The job starts at the drawing board where value begins and proceeds through acquisition of materials, tooling, machining, and assembly, at all times ferreting out unnecessary costs.

Value analysis is best applied to existing systems, and reductions are best accomplished by breaking into areas of controlled process. The ground work must be firm so that if a project is started which requires crossing organizational lines no organizational problems result. An effect program must have the team effort aspect in an organization and the team must be considerate of other departments, and above all, be very diplomatic.

Although value analysis has a long way to go to be universally accepted, it has been outstandingly successful where it has been practiced. One company reports a six-months saving of $275,000 in 50 completed projects and expects a $10–15 return on every dollar spent on value analysis. Another concern reports an actual saving of $25.72 for every dollar spent in one year. This figures out to a yield of $148,000 for every trained value specialist on the job.

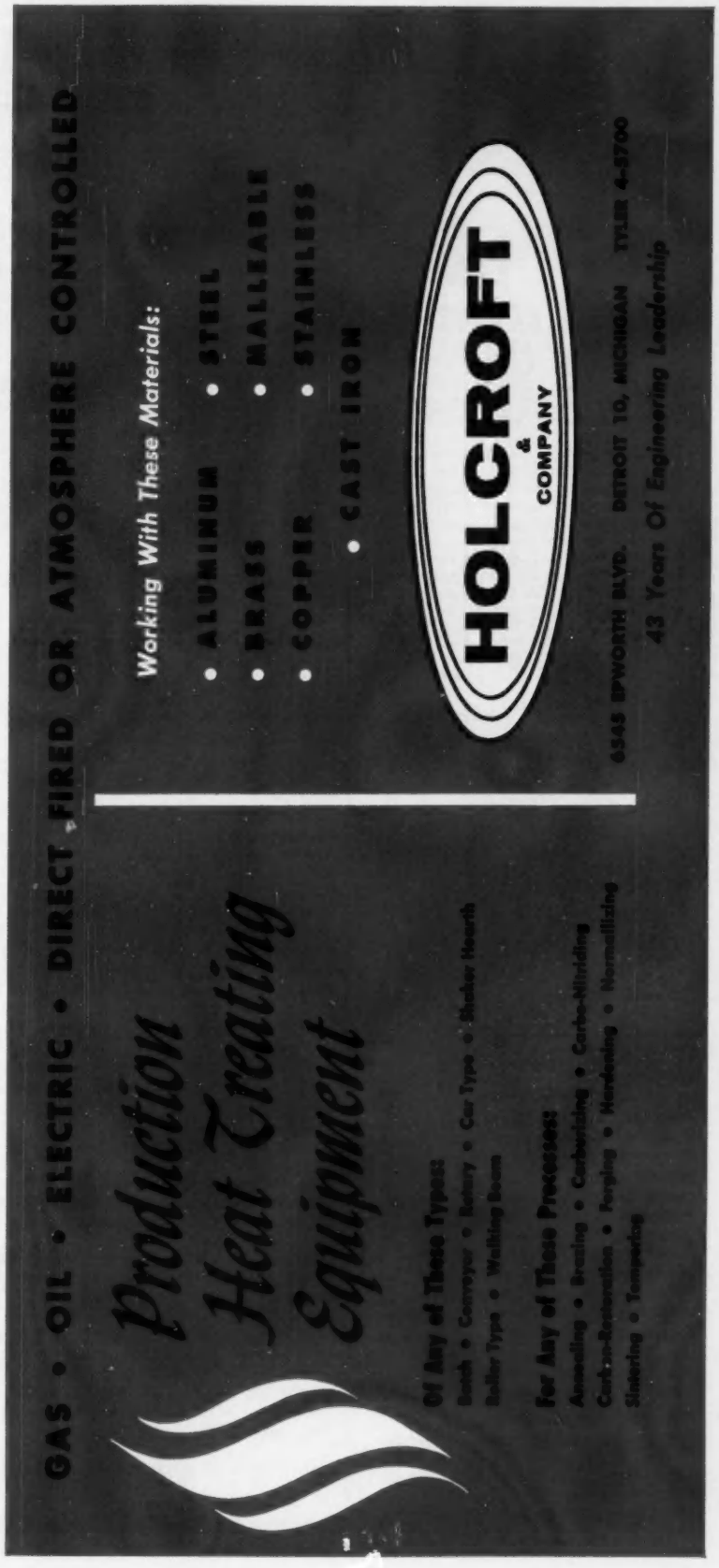
THIS ARTICLE . . .

. . . was drawn from material presented in a:

- **Paper "Value Engineering — Key to Productivity and Profitability" by John F. Prendergast, General Electric Co. (Paper No. 182A)**
- **Secretary's report of a production panel on Product Evaluation for Cost Reduction. This report, along with 11 other production panel reports, is contained in SP-330.**

The panel consisted of: N. E. Kewley and J. A. Chantry, General Electric Co; R. Lay, Cooper-Bessemer Corp.; P. Love, Cleveland Graphite Bronze Division, Clevite Corp.; W. F. Ruggles, Value Analysis, Inc.; M. Shaffer, Euclid Division, GMC; Dr. Russell L. Ackoff, Case Institute of Technology.

To order Paper No. 182A or SP-330 from which material for this article was drawn, see p. 6.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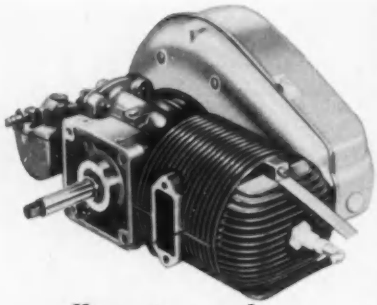

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TYPE Horizontal or vertical mounting; air-cooled; 2-cycle, clockwise or counter-clockwise rotation (at drive end).

MODELS

SERIES 390 Displacement 3.9 cu. in. Rated horsepower 1.6 at 4000 rpm.

SERIES 580 Displacement 5.8 cu. in. Rated horsepower 4.0 at 4500 rpm.

SERIES 700 Displacement 7.0 cu. in. Rated horsepower 5.0 at 4500 rpm.

IGNITION Wico flywheel type magneto.

FUEL SYSTEM Float feed carburetor is standard; diaphragm type carburetor with integral fuel pump is optional.

VALVES Reed type; corrosion resistant.

FOR MORE INFORMATION

Write for colorful illustrated catalog on West Bend's complete line of Power Bee engines. Ask about the sample engine program.

WEST BEND ALUMINUM CO.

Dept. 1415, Hartford, Wisconsin

New Members Qualified

These applicants qualified for admission to the Society between April 10, 1960 and May 10, 1960. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Atlanta Section: William S. Gray (J).

British Columbia Section: Douglas Sydney Jarman (A).

Buffalo Section: Franklin A. Higgins (M).

Central Illinois Section: Gail G. Avery (J), Stanley Patrick Mallery (A), Alfred H. Thoman, Jr. (M).

Chicago Section: Carl T. Butler (M), Philip E. Cary (M), Joseph Vincent Pizzillo (A), Joseph J. Rokos (M), Victor P. Vidugiris (J), Frederick Karl Waechter (M).

Cincinnati Section: Mel Abrams (A), Karl G. Sommer (M).

Cleveland Section: Donald Francis Avila (J), Richard K. Chamberlain (M), Richard F. Fitzgerald (M), Frank J. Hahn (A), James A. McGowan (M), Matthew Pacak (M), David H. Roberts (J), Maurice E. Selander (M).

Colorado Group: Bruce H. Gale (A).

Dayton Section: Louis F. Bolton (M), Albert T. Hart (M), Derrolle E. Haugen (J), Robert A. Manogue (M), Vernon L. Pickering (M).

Detroit Section: Jack M. Brandstadter (M), David D. Carley (J), Roy D. Chapin, Jr. (M), Charles J. DeLorean (M), Keith R. Deyo (J), E. E. T. Dulfer (J), Ricardo Felix Joseph (J), Robert F. Keefer (J), LaVerne M. Krieger (M), Frank P. Macartney (J), John D. Mall (J), John A. McClanathan (M), Donald E. McMinn (M), George H. Robinson (M), John Serbin (A), Brent D. Sherman (J), Walter J. Simons (M), James E. Steele (M), George Steinberger (M), Robert William Warnke (J).

Fort Wayne Section: Robert O. Baker (M), Kjell Pedersen (J), Cecil E. Webb, Jr. (M), Gary A. Whitcomb (J).

Indiana Section: Stanley Davis (M), Roger Kendal Easton (J), James L. Hoch (J), James F. Stafford (M).

Metropolitan Section: Albert J. Clancy (A), Birger Ganno (M), Emmett Scott Harrison (M), William J. Moses (J), David M. Roney, Jr. (M), Oliver A. Servadio (M), Robert C. Ward (A), Stephen F. Wilder (M).

Mid-Continent Section: W. J. Mocha, Jr. (A).

Mid-Michigan Section: Richard A. Murley (J).

Milwaukee Section: John J. Chyle (M), Erwin G. Dueringer (M).

Montreal Section Charles H. Duff (M).

New England Section: Joseph McBride Harris (M).

Northern California Section: Lewis C. Coffey (M), Roy Harold Kettle (M), Paul L. Markowitz (A).

Ontario Section: George Bethlendy (M), Fred W. Hall (A), William Joseph Hutchinson (A), Harold Richard McKnight (A).

Philadelphia Section: Harry John Baumbach, Jr. (M), Eugene Hindin (M), Lloyd William Hurst (M), Terence Joseph McCabe (M).

Rockford-Beloit Section: Roy A. Stone (A).

St. Louis Section: James L. Martin (M).

San Diego Section: Richard Louis Kimble (A).

Southern California Section: Clifford R. Adams (A), H. A. Armstrong (M), Robert R. Breshears (J), James F. Graham (M), Fred L. Hartley (M), Hal C. Huffman (M), Raymond H. LaFontaine (A), George Frederic Leonhard (J), Normand Earl Westmore (J).

Southern New England Section: William H. Burtt (J), Joseph W. Wells (M).

Spokane-Intermountain Section: Donald Edward Russell (M).

Syracuse Section: William A. Heater, Sr. (M).

Texas Section: Joseph Ingram (M).

Texas Gulf Coast Section: John B. Williams (M).

Twin City Section: Ray E. Brown (M), Charles E. Grimes (M), Lincoln Hudson (M).

Virginia Section: Henry Lee West, Jr. (A).

Washington Section: Robert Roger Duddy (M), Colin Willmott (J).

Wichita Section: Lester Kenneth Fortney (M).

Outside Section Territory: B. J. Green (A), Howard B. Herr (A), Rudolf Horsch (J), Howard R. Johnson (M), James F. Link (J), Ernesto G. Riefkohl (A).

Foreign: Lucien Jean Combes (M), France; Subhas Chandra Ghorai (J), England; Madhav Narayan Kango (J), India; Edmundo B. Lucius (M), Argentina; D. L. Narasimhan (J), India; Atsushi Watari (M), Japan; Maurizio Augusto Wolf (M), Italy.

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No matter what trademark you choose from the AMP catalog, you pick a mark that stands for reliability. AMPOWER, the latest in the family of AMP trademarks, embraces top quality terminals for the larger wire size range . . . conforming to NEMA specifications.

To get the finest electrical/electronic circuit termination products, to get the finest application tooling and the surest, most economical route to enduring reliability, always specify one of the trademarks of AMP INCORPORATED.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

AMP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • West Germany

STROMBERG CARBURETOR SCORES AGAIN

IN MOBILGAS ECONOMY RUN

★ Wins Top 4 Positions in Class C ★

During the 1960 Mobilgas Economy Run, Stromberg® carburetors proved once again their superior ability in delivering maximum mileage.

In the low-price, 8-cylinder field (Class C), the first four cars were equipped with Stromberg carburetors: the first- and second-place Plymouth Belvederes, and the third- and fourth-place Dodge Darts.

Stromberg carburetors helped a Studebaker Hawk to first place and a Dodge Matador to second in the low-medium price group (Class D).

Stromberg carburetors *do* deliver more mileage. The 1960 Mobilgas Economy Run proved it again!

Bendix-Elmira
Eclipse Machine Division
Elmira, New York

THE Bendix CORPORATION

Applications Received

The applications for membership received between April 10, 1960 and May 10, 1960 are listed below.

Alberta Group: William Walter Bolan

Central Illinois Section: Willis O. Schueth

Chicago Section: Edward E. Braun, James F. Davis, Richard A. Firth, Allan L. Freedy, Wayne D. Hendrickson, Leonard T. Johanson, A. W. Lawson, James W. Mueller, Evan G. Olson, Paul A. Sanders, William E. Gaskill

Cincinnati Section: James T. Dickinson, Thomas J. McGucken, Walter M. Posingies, Harry C. Rathkamp, John G. Roberts

Cleveland Section: William C. Dalton, Charles H. Junge, Paul E. Perry

Dayton Section: Joseph P. Pendergast

Detroit Section: William J. Alford, Duncan C. Augustine, Leland W. Beck, Colver R. Briggs, William Robert Buechler, Donald T. Cantrell, Daniel Chapin, Wilfred Clement, Siro Costantini, Thomas Bruce Dodson, Wayne T. Gray, William V. Hildebrandt, Sr., Robert W. Himrod, John B. Keir, Serge Kulmatycki, Robert D. Lichty, Eric B. Lomax, Earl A. Ludwig, Milton Robert Maline, Roy F. Manley, Marvin C. Marx, Roger P. Merryman, Jr., Gordon Eric Morse, Jack Odgen, Lawrence Glen Peck, Gerald R. Petrey, Orville E. Phelps, Stephen F. Selby, Michael S. Selwa, Everett H. Sharp, Edward J. Sheahan, Donald L. Shepard, Glenn Walter Steinman, Richard M. Studer, Richard L. Suter, Walker G. Thorsby, James A. Turck, James E. West, Paul Widmer, Harry Charles Moore

Hawaii Section: Curtis L. Baskin

Indiana Section: Marvin H. Birlingmair, Harold Henderson Dice, Jerry A. Dick, Victor N. Farhi, Robert W. McJones, R. W. Oyler, James B. Starr

Kansas City Section: Theodore F. Barrett, Clyde O. Johnson, Loren T. F. Flynn, Jr., James Leroy Mitchell, Robert Arnold Stinson, Ray P. Vaughn

Metropolitan Section: Lee Ballard, Robert E. Buckley, William W. B. Crickman, Malcolm D. Earle, Willard H. Keeber, Charles Krause, Robert K. Polson, F. Henry Rossire, Robert E. Ruhfel, Gordon C. Seeler, Kenneth Southall, Donald Kenneth Strout, Eugene C. Taylor, James W. Turner, Lester E. Waddington, Charles E. Ziehl

Milwaukee Section: Edwin Gardner Greenman, James E. Hill, Leonard Kube, Richard H. Lincoln, Donald G.

continued on p. 146

For greater ease in aluminum drawing

ask Oakite

OVER 50 YEARS CLEANING EXPERIENCE • OVER 250 SERVICE MEN • OVER 160 MATERIALS

Oakite DRAW CLEAN "M" gives smooth drawing of aluminum —cleans off fast

Using Oakite DRAW CLEAN "M" lubricant means a lower reject rate on drawing and forming aluminum. Reason: It clings to metal so tenaciously that pressures of 40 thousand psi, encountered in drawing and punching cannot wipe it off. The thinnest film will prevent seizure that leads to build-up, galling, and scratching.

All ingredients are soluble and, at annealing temperatures, volatile. This means that while it clings where most compounds wipe off, nevertheless, it is most easy to remove when necessary. And the residue, if left on, is not harmful to metal or personnel.

Oakite DRAW CLEAN "M" lubricant offers astonishing savings. By diluting with water in ratios as high as 1 to 9 it extends die life three times the previous experience. Miscible with both water and oil, it is adaptable to any of the following:

light stamping	stretch forming	tapping
deep drawing	tube bending	spinning
cold heading	wet grinding	punching

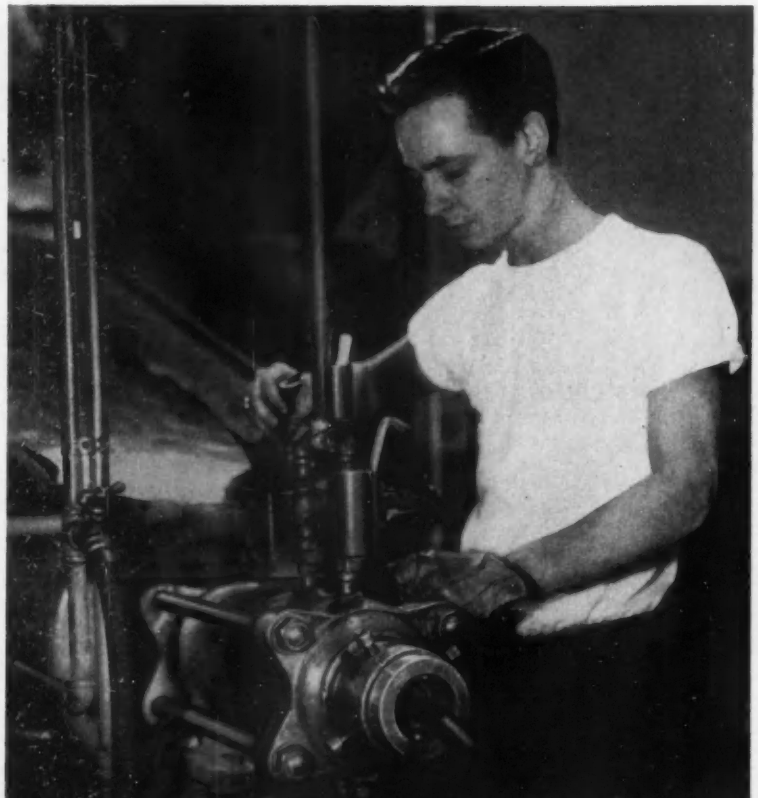
Oakite Bulletin F-10393 tells you the whole story. For your free copy ask your Oakite man or write Oakite Products, Inc., 45B Rector Street, New York 6, N. Y.

it PAYS to ask Oakite

OAKITE

over 50 Est. 1909 SCIENCE years' leadership in industrial cleaning

Technical Service Representatives in Principal Cities of U. S. and Canada



ACCURATE PRE-FORMING...

symbol of quality production

Accurate pre-forming plays an important role in developing optimum molding characteristics during the manufacture of an exacting rubber product. At PARCO, the up to date tools used in pre-forming are carefully designed and tooled to produce a pre-formed part that fits accurately into the mold cavity, assuring the ultimate in product consistency.

At the same time, the tools used by PARCO in pre-forming are designed to expedite free-flow of material during the molding process. The entire process is conducted with a strict regard for cleanliness and exactness.

This is why, at PARCO, accurate pre-forming is a symbol of quality production!

Send today for your free PARCO Pic-O-Ring desk/wall chart. A must when "O" Rings are concerned.

PLASTIC AND RUBBER PRODUCTS COMPANY

2100 Hyde Park Boulevard • Los Angeles 47, California

Applications Received

continued from p. 145

Pohl, Otto H. Scharpf, Lawrence J. Slater

New England Section: Harold J. Jordan, James C. McEvoy, Chester L. Menne, Edward H. Reichel, Thomas M. Toppin

Northern California Section: Wallace Calvin Anderson, John H. Goard, K. Bertil Klingborg, George H. Robinson

Northwest Section: Charles Raymond Hartford

Ontario Section: Earl Kitchener Brownridge, Frank X. Gregor, Albert Michael Hand, Ivor Sidney Piercy, Robert Reid

Oregon Section: Stanley R. Evans, Russell Lowell Madsen

Philadelphia Section: George W. Knoll, Stephen T. Palmer, Jr., Charles H. Raches, Jr., Earle C. Smith, Lowell Eugene Van Zandt, George E. Watson

Pittsburgh Section: Joseph M. Krippendorf

Rockford-Beloit Section: Robert Lee Kantz, Richard C. Zimmer

Salt Lake Group: Mituo Ikemoto, Robert Wallace McNamara

San Diego Section: Francis W. Blockel, Robert Bowen, Peter J. Michos

South Texas Group: Paul T. Whitmore

Southern California Section: Donald A. Domike, Samuel D. Gray, Jr., Frank O. Jappel, Jr., Jeff Moise, William Edward Pasley, T. W. Proudfoot, John R. Singer

Syracuse Section: James Owen Tennies

Texas Gulf Coast Section: Frank C. Sexton

Twin City Section: Richard Harold Lytle

Virginia Section: Israel Ipson, James E. Atkins

Washington Section: William Hardy Risteen, Bart Spano

Western Michigan Section: Hans-Rolf Hertzsch, Donald L. Swords

Wichita Section: William E. Watts

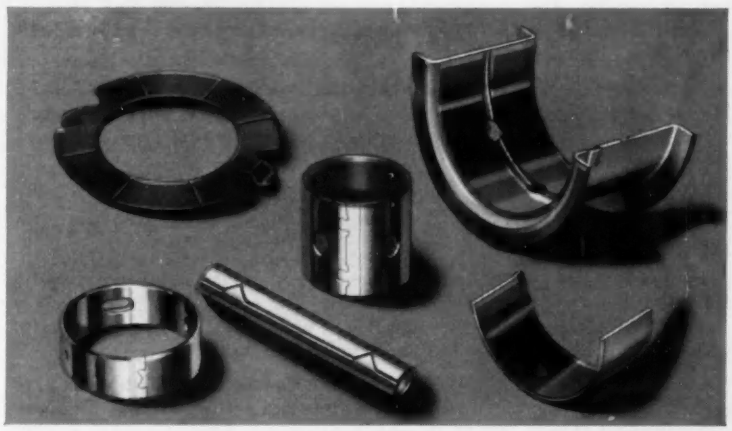
Outside Section Territory: Gerald C. Crane, Robert E. Huhnke, David E. Knapp, William F. Spaeth

Foreign: Elias Bulba, Israel; Angus Cuddon-Fletcher, England; Ernst Karl J. Gabner, Germany; Shive Dhan Gemini, India; Flaviano Moscarini, Italy

75-MILLIONTHS OF AN INCH BARRIER HALTS METAL MIGRATION

JUST BENEATH THE FRESH OVERPLATE OF THESE F-M ENGINE BEARINGS (LEFT) LIES A TENUOUS DIFFUSION BARRIER. Though this film of metal is only 75-millionths of an inch thin, it stops tin in the overplate from migrating into the lining metal beneath. Its presence is important to bearing overplate performance, particularly during the critical period of engine break-in. Maintaining uniform thinness as well as uniform composition of the plated barrier is most important . . . and most difficult to achieve on a production scale. Federal-Mogul research has developed a unique, extraordinarily precise method for controlling both the thinness and the metallic composition of this barrier, within narrow limits. And the performance of F-M engine sleeve bearings attests to the success of the method!

RESEARCH INTO ELECTROPLATING problems is a continuing project in the F-M laboratories. Unusual precision equipment and facilities are employed, many of which have been specially designed and engineered by F-M to solve problems of sliding-bearing application. As a result, Federal-Mogul engineered sleeve bearings, precision thrust washers, formed bushings, and low-cost spacers provide the finest possible performance characteristics for any application.



Have you a problem with bearings, bushings or washers? Are you considering the development or redesign of an item of the type shown above? We'll be glad to show you how the job can be done most effectively and economically. For information, write Federal-Mogul Division, Federal-Mogul-Bower Bearings, Inc., 11035 Shoemaker, Detroit 13, Michigan.

FEDERAL-MOGUL

sleeve bearings
bushings-spacers
thrust washers

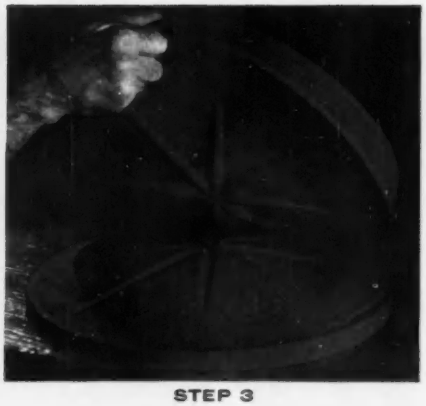
DIVISION OF
FEDERAL-MOGUL-BOWER
BEARINGS, INC.

SILICONE NEWS from Dow Corning

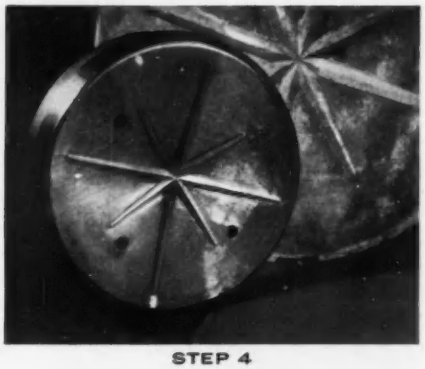
Easier Way to Make Prototypes

↑ STEP 1 STEP 2 →

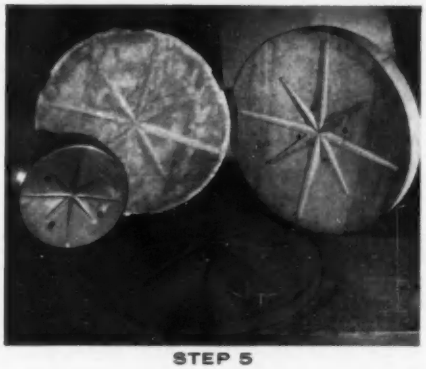
Case History: Making Hub-cap Embossing Dies



STEP 3



STEP 4



STEP 5

SILASTIC RTV SILICONE RUBBER Molds Strip Fast and Easy

Silastic® RTV, the Dow Corning liquid silicone rubber that vulcanizes at room temperature, provides a new and better way to make prototype parts. This fluid rubber is easily poured into, over, or around complex shapes, and sets up in a short time. The result is a strikingly accurate mold, into which you can pour many casting materials such as plaster, waxes or plastics. Because Silastic RTV will withstand temperatures up to 500 F, many molten metal alloys can also be cast. Silastic RTV strips readily from most materials without loss of pattern detail. Here's how one automotive industry supplier — Cadillac Stamp Co. — uses Silastic RTV to make templates for hubcap embossing dies.

Step 1. A wood pattern was machined to the exact configuration of the hubcap design. The intricate design requires a material that releases easily without loss of detail. Silastic RTV has been poured on the pattern to make a "negative" mold.

Step 2. The Silastic RTV mold is then used to cast a plastic. A "positive" image that faithfully reproduces the original pattern results. This image forms a template or prototype from which a pantograph-type engraving machine can sink dies.

Step 3. Now we return to the rubber mold, and this time more Silastic RTV has been poured into it. A rubber "positive" results. The two rubber molds release readily and two exactly matching parts result.

Step 4. From the rubber "positive", another plastic image is cast. Silastic RTV strips off easily . . . a crucial factor. The second plastic template is now ready for the engraving machine to sink dies. Size is reduced by one-half in the process. Note size of finished hubcap.

Step 5. Here are all the steps reassembled. Remember — both embossing dies were made from one wood original, thanks to Silastic RTV. Throughout the process there has been no loss of pattern detail . . . and exactly matched dies have been made.

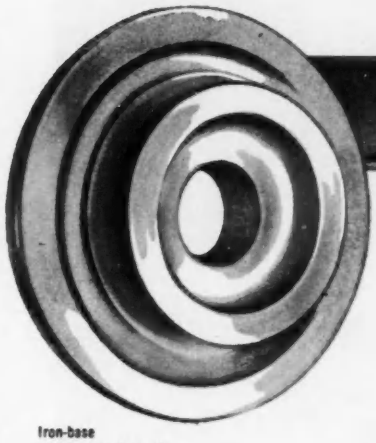
Is there a way that this easy handling and faithful reproduction can help you? We'll be glad to assist in adapting Silastic RTV to your operations.

Free Sample. Write on your letterhead for data and sample of Silastic RTV. Address Dept. 8006

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.

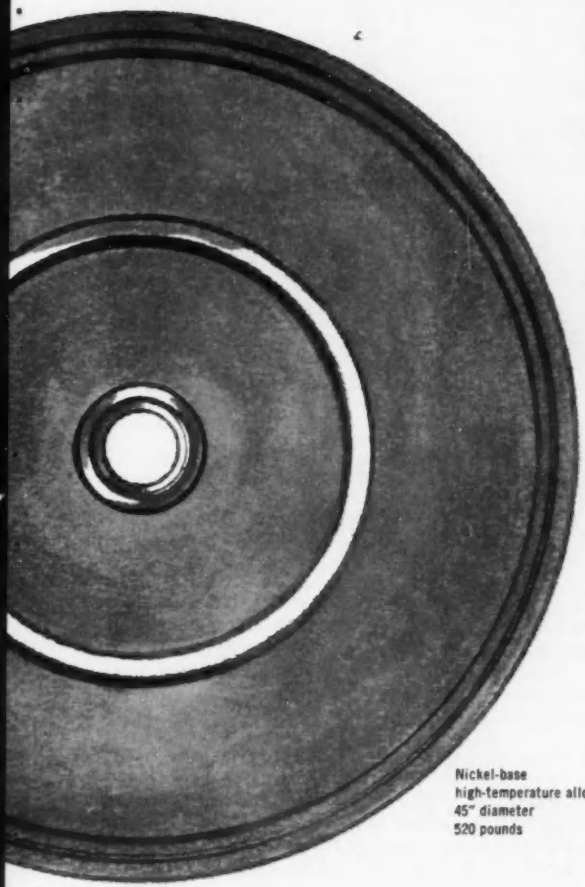


FORGED

Iron-base
high-temperature alloy
21½" diameter
244 pounds

Titanium
24½" diameter
191 pounds

To speed the progress of gas turbine development

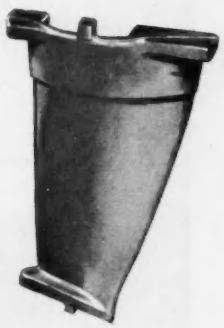


Nickel-base
high-temperature alloy
45" diameter
520 pounds

For applications ranging from automotive to aircraft propulsion, Wyman-Gordon is the world's largest producer of forged components for the gas turbine industry—turbine wheels, compressor discs, blades and vanes, for stationary turbines, nuclear installations, aircraft and missiles.

Wyman-Gordon's production experience includes forgings of a wide range of metals from low-alloy high-strength steels—titanium—intermediate temperature alloys—to the super-nickel-base alloys and refractory metals. *Guaranteed minimum properties* assure improved performance and dependability, and enable designers constantly to raise their sights and increase turbine capabilities.

With unexcelled research and production laboratories to concentrate on your development problems and with hammer and press capacity unequalled in the country, Wyman-Gordon is prepared to serve you in great depth at the design, engineering and purchasing stages of your requirements.



Titanium
15½" length

High-strength steel
19" diameter
143 pounds

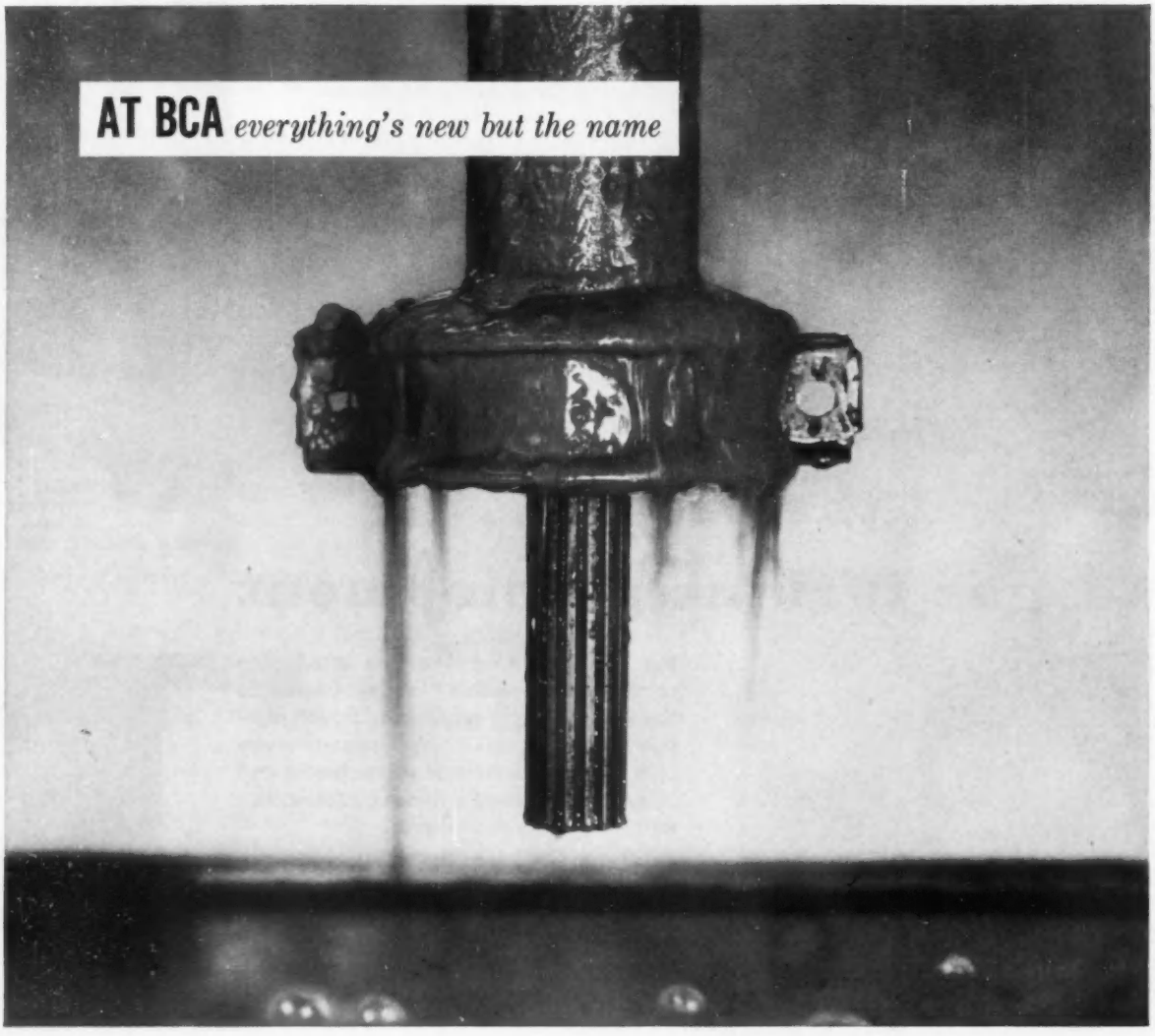
EST. 1883

WYMAN-GORDON

FORGINGS

of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

HARVEY ILL. WORCESTER MASSACHUSETTS DETROIT MICH.
GRAFTON MASS. FRANKLIN PARK ILL. LOS ANGELES CAL. PALO ALTO CAL. FORT WORTH TEX.



RARE SAND PROVES BEARING DESIGN

in new 100,000-mile test!

The automotive shaft bearing above has just completed the equivalent of 100,000 miles of dusty backroads travel. For hours, it's been alternately spun and stopped in this special mud . . . mud composed principally of a rare type of Arizona sand, *so fine it penetrates almost anywhere water can go.*

The particles of this unique sand are so small that, mixed with water, even filtering won't remove them all. They're highly abrasive, too—so much so that bearing failure quickly occurs whenever particles penetrate into a bearing raceway. Though several score of spin-and-rest cycles in this bath are equal to 100,000 miles of heavy-duty use on the road, the BCA bearings tested on this machine consistently stand up under many more cycles, before failure from sand penetration.

This test is typical of the many being conducted in BCA's new testing laboratories for BCA customers. Here, and in the expanded research laboratories, testing of bearings to exceed customer specifications is a daily occurrence. Often test equipment is specially built to exactly duplicate equipment in the customer's plant.

BCA provides a wide range of ball bearing sizes and types for nearly every kind of industry. This, plus extensive new research, testing, and precision production facilities make BCA a dependable source of long-life bearings. For information, write Bearings Company of America, Division of Federal-Mogul-Bower Bearings, Inc., Lancaster, Pennsylvania.

BCA

BEARINGS COMPANY OF AMERICA

ball bearings

DIVISION OF FEDERAL-MOGUL-BOWER BEARINGS, INC.

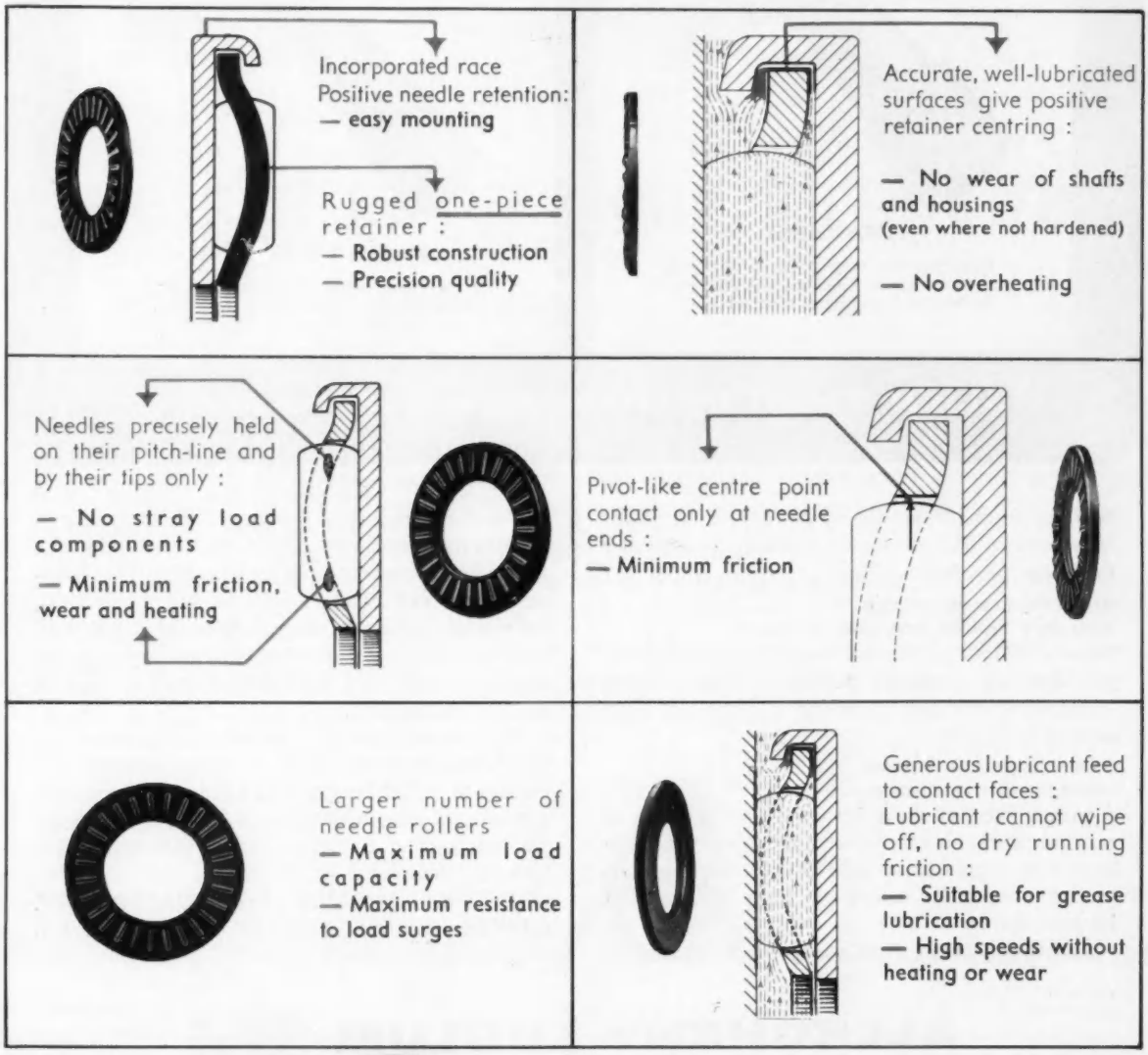
A product of

NADELLA *engineering skill*

The new

Needle Roller Thrust Bearing

Takes no more space than a washer


Incorporated race
Positive needle retention:
— easy mounting
Rugged one-piece retainer :
— Robust construction
— Precision quality
Accurate, well-lubricated surfaces give positive retainer centring :
— No wear of shafts and housings
(even where not hardened)
— No overheating
Needles precisely held on their pitch-line and by their tips only :
— No stray load components
— Minimum friction, wear and heating
Pivot-like centre point contact only at needle ends :
— Minimum friction
Larger number of needle rollers
— Maximum load capacity
— Maximum resistance to load surges
Generous lubricant feed to contact faces :
Lubricant cannot wipe off, no dry running friction :
— Suitable for grease lubrication
— High speeds without heating or wear

S.A. des Roulements à Aiguilles

NADELLA

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WHY BUY METAL YOU DON'T USE?

Switch to Allegheny Ludlum Cast-to-Shape Tool Steel

FORGING

Stepped-out forging for fabricating spinning cone: 2300 lbs.—$2691 material cost plus cost of machining.

CAST-TO-SHAPE

Cast-to-shape spinning cone 1059 lbs. $860.97 Includes cost of the pattern.

$1,831 Saved by changing to Cast-to-Shape

Why pay for metal that ends up as chips on your floor? Here are two fine reasons for switching to Allegheny Ludlum cast-to-shape tool steels.

CAST-TO-SHAPE MEANS YOU BUY FEWER POUNDS OF METAL.
Because the tool you buy is closer to its finished shape, you obviously spend less money on original metal. In the above example, the savings in metal cost alone amount to $1,894.

CAST-TO-SHAPE MEANS LESS FINISH MACHINING.
A casting like that above has only ¼ to ⅜ inches of machine stock on all surfaces, requiring very little machining compared to solid chunks. Cast-to-shape tooling is especially economical when working with intricate shapes.

Allegheny Ludlum, a tool steel producer who makes cast-to-shape materials, casts them with the same precise quality control for which their tool steels is known. A full line of cast-to-shape tool steel grades is available. You'll find ones with high resistance to abrasion, compressive strengths of approximately 400,000 psi, easy machinability, hardening with almost no distortion, toughness, high red hardness, and the capacity to take a high polish.

Find out now how you can cut costs on your complex tools. Write for FC-4, a 28-page technical discussion of A-L's Forging and Casting Division with applications, pattern information, design tips, analyses, and heat treating instructions. Or call your nearest A-L tool steel warehouse or distributor.

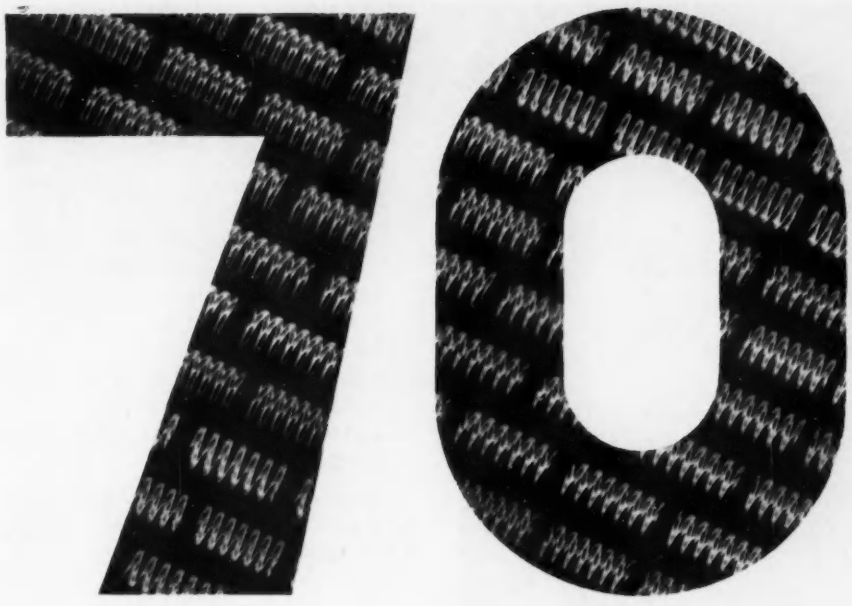
ALLEGHENY LUDLUM STEEL CORPORATION, OLIVER BUILDING, PITTSBURGH 22, PENNA.
Write to Dept. SA-6.

W&W 7270

ALLEGHENY LUDLUM

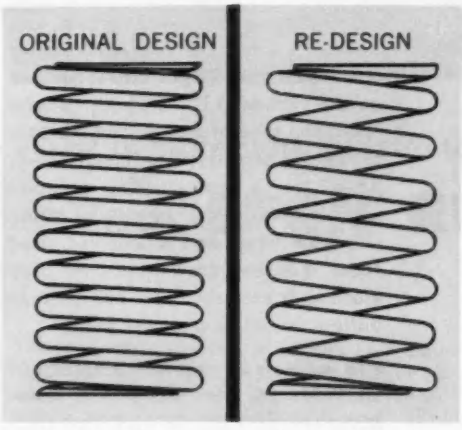
Tool Steel warehouse stocks throughout the country . . . Check the yellow pages

EVERY GRADE OF TOOL STEEL . . . EVERY HELP IN USING IT



70 POUNDS OF SPRINGS

were just going along for the ride!



10 coils—.120″ wire
130 lbs. of wire per
1M springs

7 coils—.105″ wire
60 lbs. of wire per
1M springs

Because of mounting cost conditions, a user of motor-support springs asked for a complete design check. Redesigned by A.S.C. engineers, required stresses were met by a slight change in wire size, allowing a reduction in number of coils from 10 to 7. This meant a saving of 70 pounds of material per thousand springs. Because of the shorter length of wire, coiling and grinding speeds were increased, heat-treating time reduced. Saving to the customer—40%.

How about the springs you use? A consultation on your specifications costs you nothing. Just contact any Division of Associated Spring Corporation. For a handy reference to spring action, write for "Spring Design and Selection—in brief."

5906

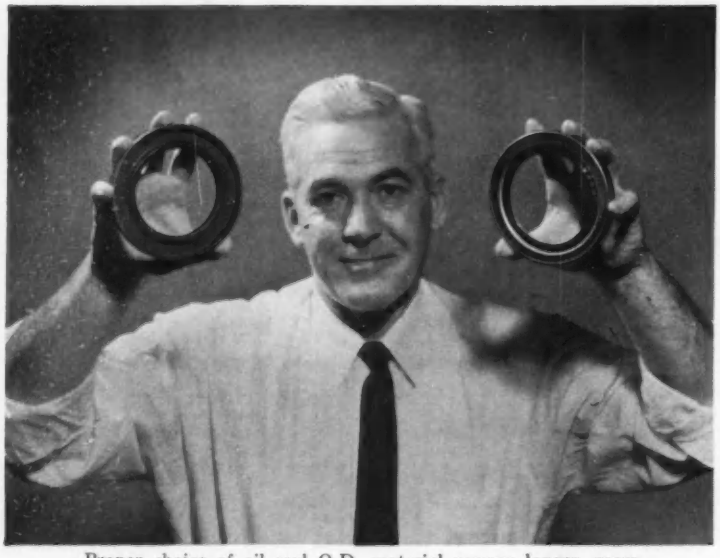
Associated Spring Corporation **General Offices: Bristol, Connecticut**

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Chicago 14, Ill.
Milwaukee Division, Milwaukee, Wis.
Raymond Manufacturing Division, Corry, Penna.
Ohio Division, Dayton, Ohio
F. N. Manross and Sons Division, Bristol, Conn.
San Francisco Sales Office, Saratoga, Calif.
Seaboard Pacific Division, Gardena, Calif.
Cleveland Sales Office, Cleveland, Ohio
Dunbar Brothers Division, Bristol, Conn.
Wallace Barnes Steel Division, Bristol, Conn.

Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que. Puerto Rican Subsidiary: Associated Spring of Puerto Rico, Inc., Carolina, P.R.

OIL SEALS

In Design Engineering



Proper choice of oil seal O.D. material assures longer, more positive bearing protection.

Steel O.D. or Rubber O.D. Oil Seals? Careful selection will assure proper performance on your application.

Rubber should be used only for soft housing materials such as zinc, magnesium or aluminum. In a molding process, rubber is shaped and sized by heat and pressure. These same factors exist when a seal with a rubber O.D. is applied in a steel housing . . . pressure is created by the normal press fit of the seal, heat by the location of the seal in the unit. Under these near-perfect molding conditions, the rubber O.D. seal re-forms to bore size, thus causing leakage at the bore.

Steel, on the other hand, should not be used in a housing made of soft material. In this case, the harder steel would tend to reshape the softer housing, causing a variety of problems.

In seals with both rubber and steel O.D.s, Garlock offers a complete line of high-quality KLOZURE* Oil Seals. They do a complete job of protecting bearings, sealing in vital lubrication, sealing out harmful dirt and foreign matter. During design, contact your Garlock representative for his recommendation on the best seal for your application. It costs no more to get his suggestions on the type of O.D., the seal material itself, the type of spring, and whether to use an assembled or bonded seal. Then, too, a new stocking program assures prompt delivery of KLOZURE Oil Seals when and where you need them. You can draw from over 2300 stock seals available from 180 national outlets, including one near you.

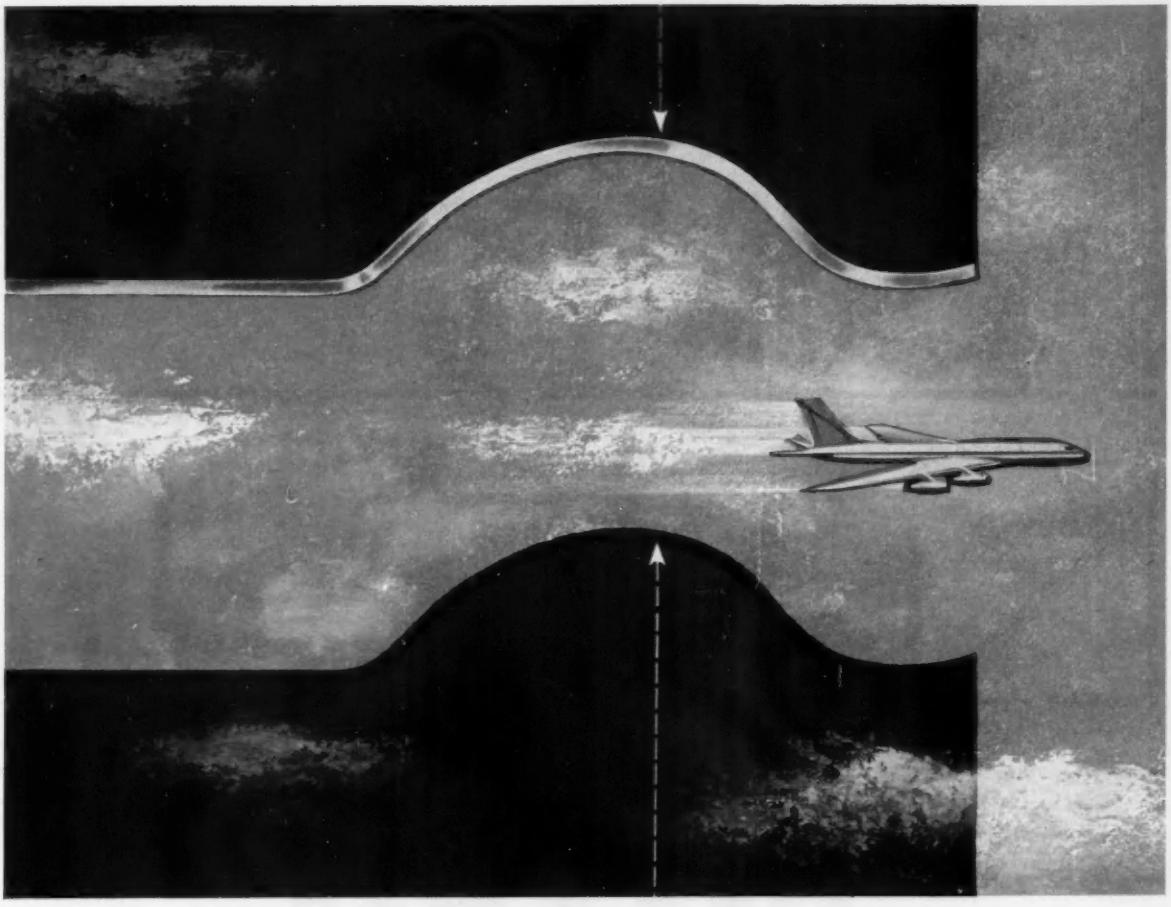
Find out more by calling the nearest of Garlock's 26 sales offices and warehouses throughout the U.S. and Canada. Or, write for KLOZURE Catalog 30. Garlock Inc., Palmyra, N.Y.

GARLOCK

Canadian Div.: Garlock of Canada Ltd.

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products

*Registered Trademark



Want to save with plastic tools and dies?

Your EPON® RESIN tooling formulator can help you

Tools and dies made of tough but easy-to-handle Epon resin can save you up to two thirds in time, one third in cost! Your tooling resin formulator will show you how Epon resin formulations are saving time and money—*right now*—in applications such as:

High-temperature tooling: Metal-forming stretch dies that can operate at temperatures over 400° F.

Heated tools: Matched dies, with integral heating units, may be made with Epon resin formulations for rapid heat-curing of laminated plastic parts.

Long-lasting metal-forming tools: Castings made of formulated Epon resin, mounted in a crank press, showed no permanent deformation after 28,000 compression-shock cycles.

For tool and die applications, Epon resin formulations offer you the following important advantages:

Excellent tolerance control: Little machining and handwork are required to finish Epon resin tools because of the material's excellent dimensional stability and lack of shrinkage.

Outstanding strength: Jigs and fixtures with thin cross sections can be built from Epon resin-based formulations reinforced with glass cloth. The resulting laminate has high flexural strength and excellent dimensional stability.

Easy modification: Tools and fixtures made from Epon resins may be quickly and easily modified to incorporate design changes.

CONTACT YOUR TOOLING RESIN FORMULATOR

The combination of resin formulator's skill and application knowledge, backed by Shell Chemical's research and resin experience, has solved many important tooling problems for industry. For a list of experienced tooling resin formulators and additional technical information, write to:

SHELL CHEMICAL COMPANY

PLASTICS AND RESINS DIVISION

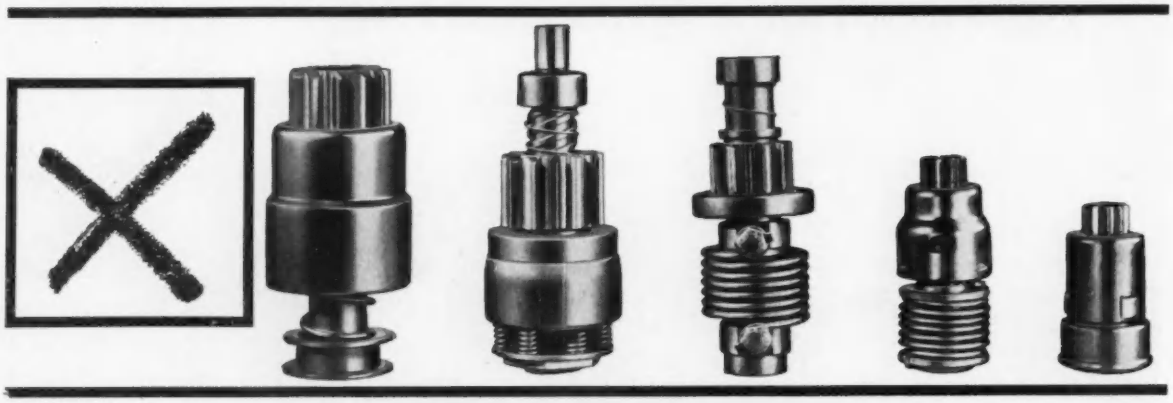
110 WEST 51ST STREET, NEW YORK 20, NEW YORK

Central District	East Central District	Eastern District	Western District
6054 West Touhy Avenue	20575 Center Ridge Road	42-76 Main Street	10642 Downey Avenue
Chicago 48, Illinois	Cleveland 16, Ohio	Flushing 55, New York	Downey, California

IN CANADA: Chemical Division, Shell Oil Company of Canada, Limited, Toronto

SHELL

BENDIX
STARTER DRIVES



VOTED NUMBER ONE
OVER 130,000,000 TIMES

The selection of Bendix* Starter Drives for over 130,000,000 *automotive vehicle* installations speaks for itself on the kind of performance these Drives deliver. They're first choice, too, for aircraft, locomotives, inboard and outboard motors, and earth movers. In short, whatever the type of internal-combustion engine, you can start it *better*—more dependably and at lower cost—with a Bendix Starter Drive.

*REG. U.S. PAT. OFF.

Bendix-Elmira
Eclipse Machine Division
Elmira, New York

TOMORROW'S "DREAM" IS OUR JOB TODAY

There's more to the car of tomorrow than just futuristic styling! Automotive engineers are working constantly to perfect completely new power plants—like turbine engines—to achieve yet unheard of performance and economy! And they demand bearings that are as advanced as their thinking. This is no new challenge to Bower engineers. Their many original contributions have helped increase performance and reduce bearing failure to a minimum. If your product is one which requires advanced bearings today plus realistic planning for the future, call Bower. There's a complete line of tapered, straight, or journal roller bearings for every field of transportation and industry. Bower Roller Bearing Division, Detroit 14, Michigan.

BOWER
ROLLER BEARINGS

tapered cylindrical journal

DIVISION OF
FEDERAL-MOGUL-BOWER
BEARINGS, INC.

'ROUND-THE-CLOCK DEPENDABILITY is one reason why the petroleum industry specifies Bower roller bearings.

LEADING HEAVY EQUIPMENT MANUFACTURERS use Bower roller bearings—for long, efficient life under punishing loads.

REDUCE BEARING MAINTENANCE—Use Bower tapered and cylindrical roller bearings for your application.

Naugatuck KRALASTIC
HYGA BURRO
Announcing
KRALASTIC MH
...newest in the
family of
Design-Engineering
ABS Plastics
• HIGH GLOSS
• EASIER PROCESSING
• FASTER MOLDING
• EXCELLENT APPEARANCE

Newest in the constantly expanding family of tough KRALASTIC® compounds, the original ABS resins, KRALASTIC MH has been developed especially to meet the requirements of those whose operations call for faster production cycles.

Yet with all its ease of processing, it sacrifices none of the impact strength which has made KRALASTIC the preferred material for hundreds of toughness-demanding applications.

In addition to its unusual combination of processability and impact strength, KRALASTIC MH also offers a high heat stability exceeding that of many other plastic materials. And its ability to take and hold a high gloss produces a lustrous product with strong and lasting sales appeal.

MH shares with the other KRALASTICS such typical properties as wide chemical resistance, unusual ability to withstand abrasion, and good electrical characteristics. These properties recommend this new material highly for sheet and profile extrusions, injection moldings . . . for a wide variety of products ranging from appliance housings to shoe heels.

Send for further information on the properties and application possibilities new KRALASTIC MH offers.

Naugatuck Chemical Division, United States Rubber
Dept. 6, Elm Street, Naugatuck, Connecticut

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

US RUBBER

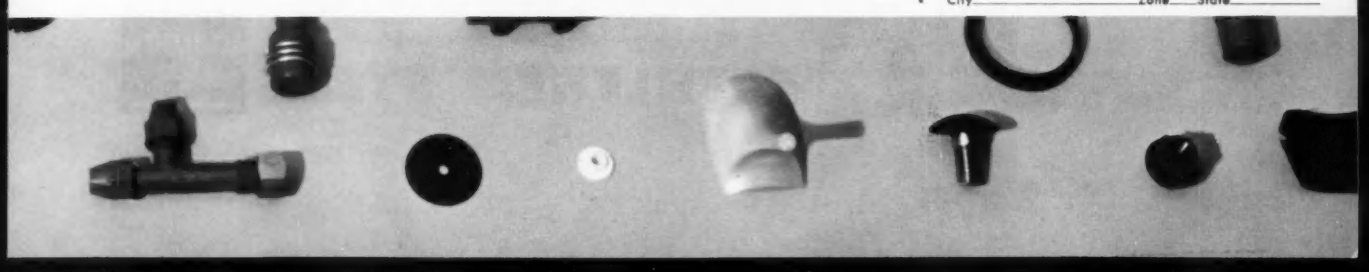
United States Rubber

Naugatuck Chemical Division

DEPT. A ELM STREET
NAUGATUCK, CONNECTICUT

KRALASTIC RUBBER-RESINS • **MARVINOL** VINYLS • **VIBRIN** POLYESTERS

Akron · Boston · Gastonia · Chicago · Los Angeles · Memphis · New York · Phila.
CANADA: Naugatuck Chemicals · Elmira, Ont. · Cable: Rubexport, N.Y.



KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Normalizing Alloy Steels

There are several forms of heat-treatment commonly employed in the processing of alloy steels. Each in its own way modifies the mechanical properties and structures of steel, and each is chosen with a definite objective in mind. The five usual forms of treatment are normalizing, annealing, spheroidize-annealing, quenching and tempering, and stress-relieving.

In this particular discussion, let us consider briefly the purposes and effects of normalizing.

Normalizing is an operation in which the steel is heated to approximately 100 deg F above the upper transformation range, then cooled in still or agitated air. The basic purpose is to refine the prior structure produced by variations in finishing temperatures encountered in rolling or forging. The structure resulting from normalizing, being more uniform, will help create improved mechanical properties when the steel is subsequently reheated, liquid-quenched, and tempered.

There are times when large steel parts (heavy forgings, for example) cannot be liquid-quenched because of their size. In cases of this nature, the heat-treatment must consist of single or multiple normalizing followed by tempering.

High-temperature normalizing is sometimes used for grain-coarsening low-carbon alloy steels to promote machinability. (In high-temperature normalizing, steel is heated to more than 100 deg F above the upper transformation range.) At times it is possible to machine a steel in the air-cooled condition, the governing factor being the alloy content. However, the highly alloyed analyses may require annealing or tempering after normalizing, to decrease the hardness.

It is essential, when normalizing is employed, that free circulation of still or agitated air be provided. When air-cooling of individual bars or forgings is not practicable, the furnace charge should provide for some means of separation, such as racks or spacers.

If you would care to know more about normalizing, or any other phase of heat-treating, you are invited to consult with Bethlehem metallurgists. They are always glad to give you any help you need.

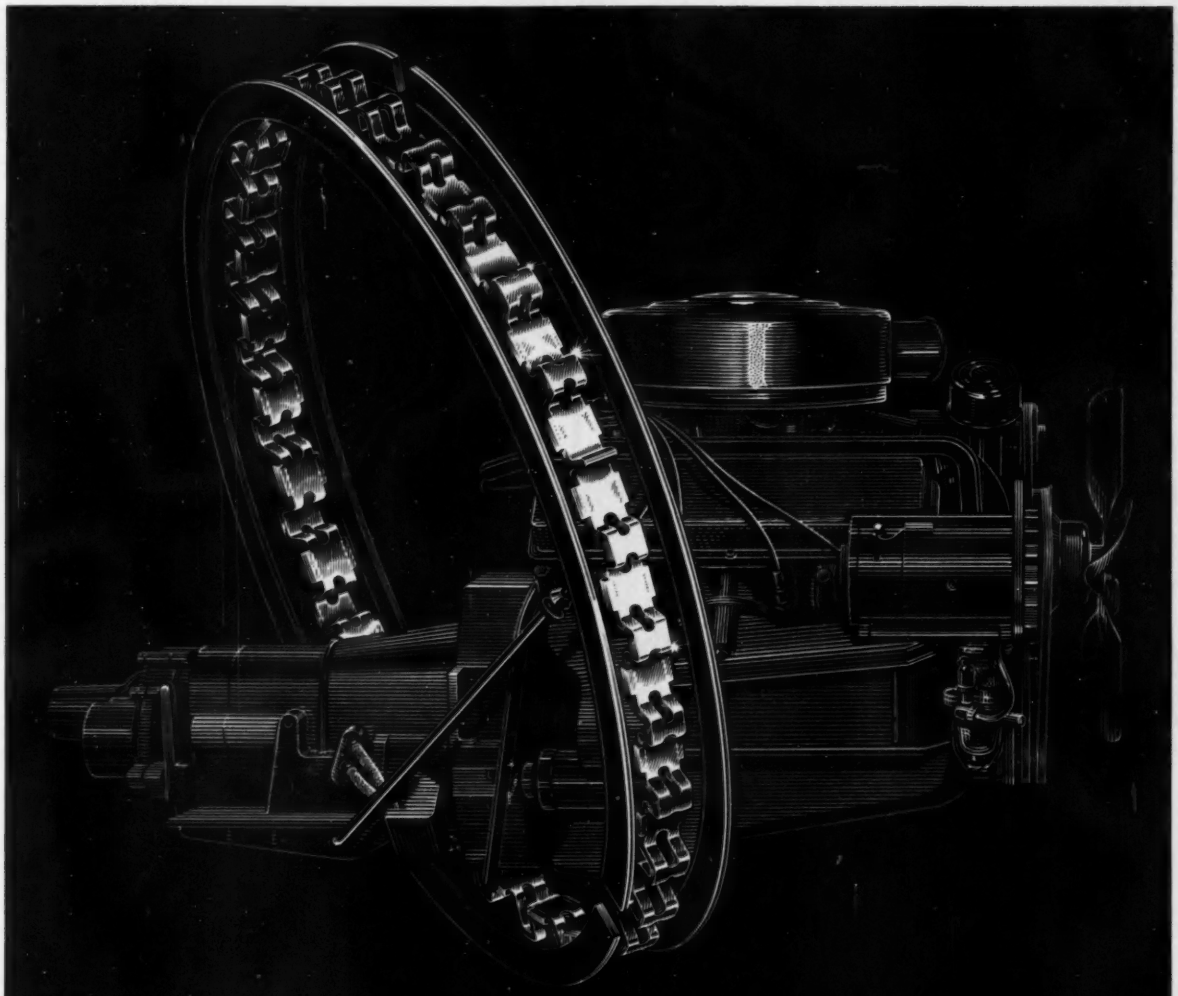
And remember that Bethlehem makes the full range of AISI standard alloy steels, as well as special-analysis steels and all carbon grades.

This series of alloy steel advertisements is now available as a compact booklet, "Quick Facts about Alloy Steels." If you would like a free copy, please address your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL



Helping solve knotty problems is Sealed Power's business

STAINLESS STEEL OIL RING, U. S. PAT. NO. 2,789,872

Specialized research, engineering, manufacturing, and service. A lot of specialization, you may say. It is, but we feel this is the way the ball bounces in the ring business. The way the ball *has to* bounce, if we expect to continue our historic association with engine builders. And we do.

We take most pride in your assignments which have been out of the ordinary. Licking these problems is what spread the word in the industry: "Sealed Power can give you production, alright; but if your problem requires resourceful engineering . . . or application of unusual manufacturing techniques . . . exceptional quality control—these are the people to see."

This is our reputation. Only by continuing to solve the knotty ones can we retain it.

Sealed Power

Preferred Performance through Engineering and Research

SEALED POWER CORPORATION, MUSKEGON, MICHIGAN • ST. JOHNS, MICHIGAN • ROCHESTER, INDIANA • STRATFORD, ONTARIO • DETROIT OFFICE • 7-256 GENERAL MOTORS BUILDING • PHONE TRINITY 1-3440

PISTONS • PISTON RINGS • SLEEVES • SLEEVE ASSEMBLIES • SEALING RINGS FOR ALL APPLICATIONS

Rochester-GM Carburetors are tested on grades much more severe than the average motorist encounters. They must pass such tests so that all the GM cars equipped with these superlative carburetors will always make the grade . . . with *plenty to spare!* At the General Motors Proving Ground, Milford, Michigan, we use the extra steep road inclination shown above to test Rochester-GM Carburetor function under an extreme deviation from level. Since this is only one of a complete series of quality control and operational tests on Rochester-GM Carburetors, you can see why they have won a reputation for reliability and become America's number one original equipment carburetors. That's also why they help you make the grade saleswise . . . *and then some!*
Rochester Products Division of General Motors, Rochester, New York.

GM
GENERAL MOTORS CAR

America's
number one
original equipment
carburetors

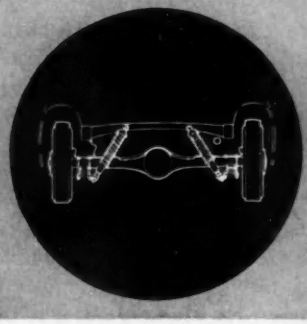
ROCHESTER CARBURETORS

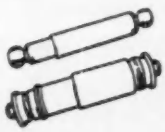
LOAD-LEVELERS*

—Monroe stabilizing units with built-in ride control for a level ride under all road and load conditions

- ✓ **Do the work of elaborate suspension systems —at a fraction of the price.**
- ✓ **Prevent "tail drag", side sway, and "bottoming" on axles.**
- ✓ **Prevent hard steering and excessive tire wear.**
- ✓ **Require no service, and don't interfere with under-body servicing.**
- ✓ **Easily installed as optional equipment at factory or car dealers.**

TYPICAL INSTALLATION: Monroe Load-Levelers are installed in exactly the same position and on the same mountings as the rear shock absorbers. They automatically compensate for all road and load conditions, provide maximum stability.





MONRO-MATIC SHOCK ABSORBERS—Standard on more makes of cars than any other brand.

DIRECT ACTION POWER STEERING—The only truly direct-action Power Steering units available.

MONROE SWAY BARS—Specified as standard equipment on 15 makes of passenger cars.

E-Z RIDE SEATS—Standard on more tractors than all other seats of this kind combined.

MONROE AUTO EQUIPMENT COMPANY, Monroe, Michigan

In Canada • Monroe-Acme, Ltd., Toronto

MONROE *World's largest maker of ride control products*

*Trademark

HOW DOEHLER-JARVIS' DAY-TO-DAY SERVICE HELPS MELNOR MASS PRODUCE HIGH QUALITY LAWN EQUIPMENT

Melnor Industries, Inc., is the leader in garden sprinklers and related hose hardware . . . items designed to high mechanical standards, modernly styled, priced for volume sale.

From the start, most parts of most items in the Melnor line have been die cast by Doehler-Jarvis . . . for reasons that Melnor sums up in the simple phrase, "day-to-day service."

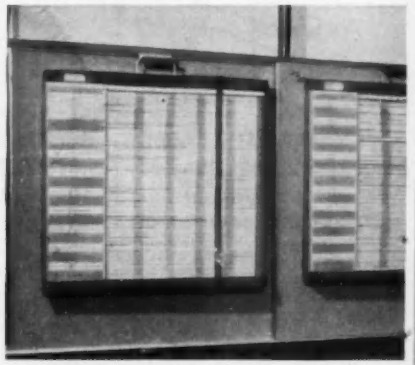
But this is a phrase that needs illumination, needs specifics.

Just what does Doehler-Jarvis include in this "day-to-day service" that means so much to die castings customers? As you might expect, Doehler-Jarvis provides all customary services, such as tapping, drilling, milling and other pre-assembly work. Doehler-Jarvis provides important extras, too . . . extensive assistance in parts design, for example, and complete finishing facilities. Even sub-assembly may be negotiated, if desired.

But more important than these is a sort of informal "partnership for production" . . . where key people in D-J keep in daily touch with their opposite numbers . . . with D-J's sales engineer coordinating all along the line. Through this mutual understanding and interchange of process knowledge, design is continually improved, costs continually reduced. Often difficulties are anticipated and entirely avoided by the close *personal* contact that exists at all working levels with Doehler-Jarvis customers.

Pictures at right show some of the points of contact . . . show some of the Doehler-Jarvis facilities that make this unique working relationship pay off for Melnor . . . as a comparable relationship might for you.

Close liaison during die design does much to keep Melnor's costs down. At this stage slight modifications in die or part often eliminate one or more operations. To attain this flexibility, D-J designs and makes its own dies.



Coordinated production is achieved simply. It's done by a daily telephone call that establishes Melnor's needs for the next two days.

Doehler-Jarvis

Division of
NATIONAL LEAD COMPANY
General Offices: Toledo 1, Ohio
Plants at:
Toledo
Grand Rapids 2, Mich.
Pottstown, Pa.
Batavia, N. Y.

In Canada: **Barber Die Casting Co. Limited**
Hamilton, Ontario

In Brazil: **Industrias Doehler do Brasil, S. A.**
Sao Bernardo do Campo, Sao Paulo

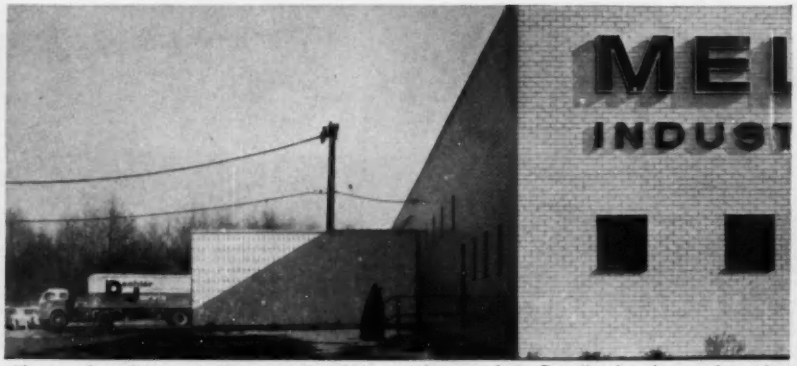
Idea exchange starts early! You are looking in on a tough-minded, sharp-pencil work session. At this one, Melnor and Doehler-Jarvis decision makers are setting basic production requirements for a new sprinkler model. During production informal meetings between individual members of this group will keep production moving smoothly.

Joint meetings establish production cost limits. Then D-J automates to bring costs within requirements. Ordinarily, automatic tooling is developed and made in Doehler-Jarvis' own shops... as was this 12-station, indexing tool.

Two heads have proved better than one in giving Melnor products durable low-cost finishes, so specialists from both companies confer frequently. D-J both plates and paints. Modern inspection guards finish quality.

Mutual considerations bring packing innovation. Until recently, D-J shipments went to Melnor in throw-away packages. To save money and time at both plants, D-J engineers designed the money-saving re-use container above.

Before closing, D-J has its trucks loaded for the next day's delivery and has started preparing shipments for the succeeding day.



Plant-to-plant delivery is direct and fast. Shipments to Melnor go in one or more of Doehler-Jarvis' own tractor-trailors, arriving early in the morning. Coordination is so close that neither plant is called upon to carry high parts inventories.

Now you can get standard sizes in C/R End Face Seals!

C/R
STANDARD
END FACE SEALS
maximum sealing efficiency in minimum space
• ¾ to 4 inch shaft sizes
• pressures to 500 psi.
• temperatures to 500° F.
• peripheral speeds to 15,000 FPM.
• external or internal pressures
2 complete series . . . long and short . . . pre-engineered to meet the widest possible range of sealing requirements. Standard mating rings also available.
Special End Face Seals . .
For special sizes and extreme conditions other than those for which the C/R standard end face seal was designed, C/R will continue to develop new seals or recommend existing designs. C/R's years of sealing experience assure you of the right seal for your job.
CHICAGO RAWHIDE MANUFACTURING COMPANY
1301 Elston Avenue
Chicago 22, Illinois

Chicago Rawhide now announces the availability of a complete new line of Standard End Face Seals to meet the widest possible range of sealing requirements. For sizes or conditions beyond the range of Standard End Face Seals, C/R engineers will continue to cooperate with you on special designs. Their experience in sealing applications is unmatched — your assurance of getting the correct seal for the job.

Write for your free copy of this new C/R Bulletin ⟶

Bulletin EF-100 includes complete envelope space data on C/R Standard End Face Seals and mating rings to help you select the correct size for your equipment design:

- Size range table in two series — long and short — from ¾ to 4 inch shaft diameter.
- Size range table on mating rings.
- Typical seal installations for internal and external pressure.
- Special instructions on how to order.

C/R

CHICAGO RAWHIDE

CHICAGO RAWHIDE MANUFACTURING COMPANY
1243 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
In Canada: Manufactured and Distributed by Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario.
Export Sales: Geon International Corp., Great Neck, New York

C/R PRODUCTS: C/R Shaft and End Face Seals • Sirvene (synthetic rubber) molded pliable parts • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-Metallic Gears

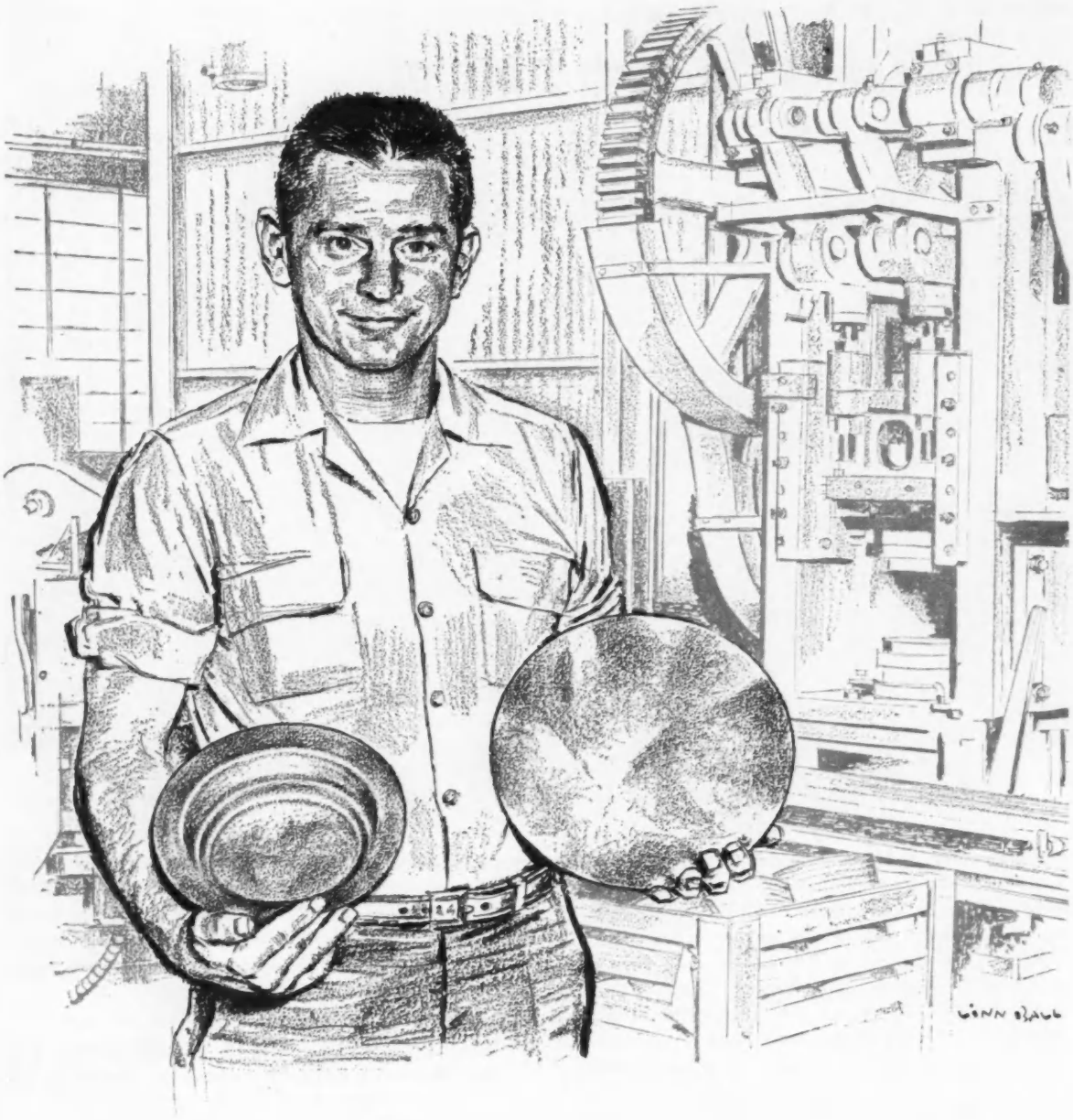
TROUBLE—FREE

SMOOTH—OPERATION

Manufacturers of the big diesel trucks, that must stand up under hour-after-hour of gruelling service, have learned to rely upon MECHANICS Roller Bearing UNIVERSAL JOINTS to deliver hundreds of thousands of miles of trouble-free service. Because MECHANICS JOINTS drive through KEYS—instead of bolts—they stand up under punishment that shears off other types of fasteners. They are designed with less parts and connections for easy assembly and servicing—smooth running balance—maximum strength with less weight—and long, trouble-free, safe operation. Rugged stamina is just one of the advantages you get when you specify MECHANICS Roller Bearing UNIVERSAL JOINTS. Let MECHANICS engineers help you design this and other competitive sales features into your product's transmission train.

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2022 Harrison Ave., Rockford, Ill.
Export Sales: Borg-Warner International
36 So. Wabash, Chicago 3, Illinois

MECHANICS
Roller Bearing BW
UNIVERSAL JOINTS
For Cars • Trucks • Busses and Industrial Equipment



"We have learned to rely on Sharon for top quality Stainless Steels"—

JOHN SHRAGG, Foreman of the Press Dept., Ekco Products Company

"Modern utensil design calls for real workable stainless steels," says John Shragg, press room foreman at Ekco Products Company's Massillon, Ohio, plant. "For consistently fine quality," he continues, "we have found we can always rely on the *Sharon Steel Corporation, Sharon, Pa.*"

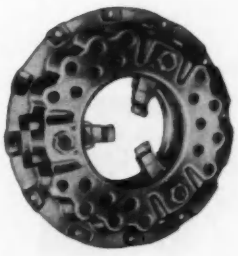
SHARONSTEEL **SHARON** *Quality* **STEEL** Steel

When They Compare for

Clutch Torque Retention

...Fleet Operators Switch to LIPE!

Torque retention is an important matter to the steadily growing body of fleet owners who are changing over to Lipe. Their every-day experience tells them that Lipe Heavy-Duty Clutches mean *more* miles per gallon of fuel . . . *more* ton-miles between shop-stops . . . *more* capital-equipment-use per repair dollar. All because of Lipe's high retention of torque capacity. Why argue with these practical men? Give them what they want: Lipe Heavy-Duty Clutches, either as original or optional equipment. Let their growing numbers prove to you that *the trend is to* LIPE!



Lipe Heavy-Duty DPB Clutches are available in single and two-plate types; 12", 13", 14" and 15" sizes; with torque capacities from 300 to 1900 ft.-lbs.

Lipe-ROLLWAY CORPORATION SYRACUSE 1, N.Y.

ADHESIVE PROBLEMS SOLVED HERE

Here in the adhesives laboratory at Bridgeport, Conn., Raybestos-Manhattan engineers can solve even your most difficult adhesive problems quickly and economically.

R/M manufactures a wide range of Ray-Bond® adhesives. For special requirements, R/M will tailor special adhesives . . . designed to meet your particular manufacturing techniques, the demands of the materials you are using, and the service conditions of the product itself.

R/M offers these 7 basic classes of adhesives, coatings and sealers:

1. Heat-setting synthetic-resin adhesives, coatings and sealers
2. Cold-setting synthetic-resin adhesives
3. Heat-setting synthetic-resin, synthetic-rubber adhesives
4. Cold-setting synthetic-resin, synthetic-rubber adhesives
5. Rubber-base adhesives
6. Synthetic-resin sealants and coatings
7. Epoxy-base adhesives, coatings and sealers; casting, encapsulating and potting compounds

Take advantage of R/M's more than 20 years of experience in the production of bonded assemblies and the manufacture of adhesives, coatings and sealers. Why not call on Raybestos-Manhattan engineers today, without obligation, and ask them to prove how they can help you cut costs, speed production, and simplify fabrication and assembly operations.

R/M Bulletin No. 700 contains helpful engineering information on Ray-BOND adhesives, protective coatings and sealers. Write for your free copy.

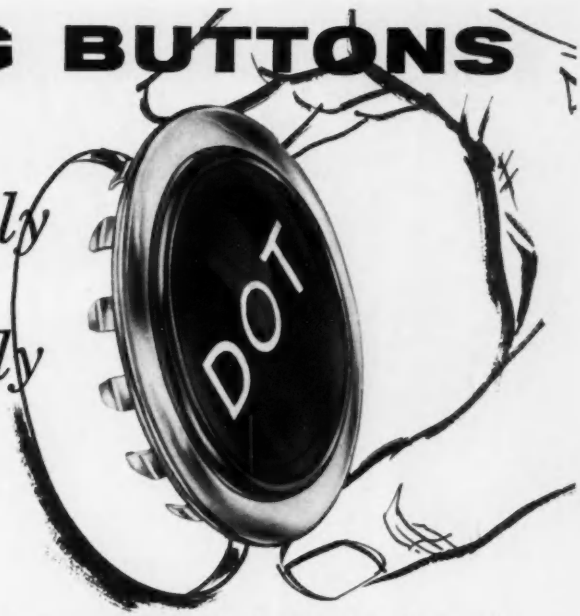
RAYBESTOS-MANHATTAN, INC.

ADHESIVES DEPARTMENT, Bridgeport, Conn. • Chicago 31 • Detroit 2 • Cleveland 16 • Los Angeles 58

R M

DOT PLUG BUTTONS

fill holes functionally and decoratively



Inexpensive DOT Plug Buttons are ideal for covering drilled or molded holes in metal or plastic structures of all types. Finger pressure snaps them into place, spring tension holds them there without rattling even under conditions of severe vibration.

Used as covers for inspection or maintenance-access holes, Plug Buttons are easily removed and can be re-inserted repeatedly without lessening their effectiveness. Used in combination with plastic lens inserts, Plug Buttons make excellent indicator-light covers. Faceted, Fresnel-type or plain lenses can be made in a variety of colors and can be designed to show words, letters or symbols, according to the requirements of the particular application.

DESIGN ENGINEERING SERVICE

Designers, metallurgists and plastics specialists on DOT's engineering staff are equipped to work out optimum combinations of metal and plastics to suit your particular requirements. Hundreds of variations in shape, finish and material are possible.

The basic steel or brass Plug Button, for example, can be parkerized or polished or finished in chrome, nickel, zinc, copper or any of a wide variety of colored enamels. Designs can be stamped into the metal or molded Lucite lenses can be inserted.

Nylon, polystyrene or flexible polyethylene Plug Buttons can be molded to show trademarks, indicator symbols or any other design.

For further details, write for Engineering Data Catalog, Section D

MAKERS OF DOT FASTENERS

CARR FASTENER COMPANY

Division of United-Carr Fastener Corporation, Cambridge 42, Mass.

Offices In: Atlanta, Boston, Chicago, Cleveland, Dallas, Detroit, Kalamazoo, Los Angeles, Louisville, New York, Philadelphia, Syracuse

Advanced hot gas systems delivered by AiResearch

FOR OUTER SPACE, ATMOSPHERIC AND UNDERWATER STEERING

AiResearch is now in production on two greatly simplified hot gas steering control systems: a reaction control system for outer space flight stabilization and a hot gas actuator control system for terrestrial steering (in the atmosphere and under water).

Both systems eliminate any need for pumps, heat exchangers, accumulators and other apparatus required in earlier control systems. And both systems utilize hot gas, operating off either the main engine or a separate fuel source.

The gas in the outer space reaction control system is fed into a set of nozzles which imparts spin to the missile to stabilize its flight through space.

In the terrestrial hot gas actuator control system the gas is fed into an on-off controlled linear actuator which moves the fins controlling the missile's attitude in the atmosphere or under water. This system also utilizes a concept developed from the AiResearch hydraulic "printed circuit." This approach eliminates complicated plumbing, thereby decreasing the weight and increasing the reliability of the system.

AiResearch is a pioneer, leading developer and manufacturer of hot gas systems and other nonpropulsive power systems for atmospheric, underwater and outer space missions. Your inquiries are invited.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

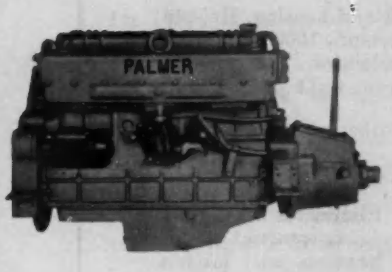
Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

MARINE POWER

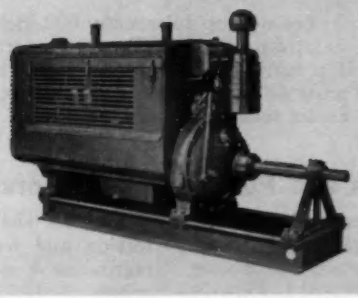
CONSTRUCTION POWER

GROUND SUPPORT POWER

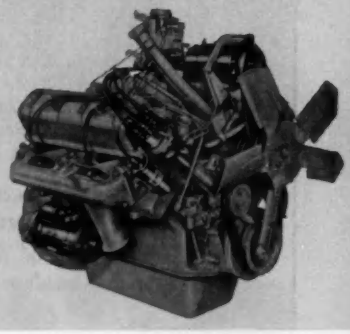
"Our sales have increased over 500% since we began using International engine assemblies five years ago." Report from R. C. Bolling, President, Palmer Engine Co.



"International diesel engines meet our standards for efficiency, dependability and parts and service coverage." Report from Guy Banister, Chief Technical Engineer, Barber-Greene Co.



"The wide range of power in the International line fits in with our plans to offer a wide selection of models." Report from Roger Frantz, Design Engineer, Hobart—Motor Generator Corp.



LEADING ENGINEERS

choose International Power for a wide variety of jobs!

Efficient and dependable power is assured for products of leading engineers, who specify IH engines for a wide variety of applications. Design engineers serve many different industries, but they all have one common problem: to find the most practical, economical and efficient power for their products. If you have the responsibility for selecting the power for your products it will pay you to check International engines because—

FIRST, you have a wide selection of power from which to choose—35 engines from 16.8 to 385 max. hp—available in gasoline, LP gas, natural gas or diesel.

SECOND, IH engines meet rigid requirements of economy and dependability. Millions of hours of continuous operation in all parts of the world have job-tested International power on every heavy-duty application.

THIRD, your customers never have to wait for replacement parts. International's world-wide parts and service facilities back up your organization with fast assistance on power problems.

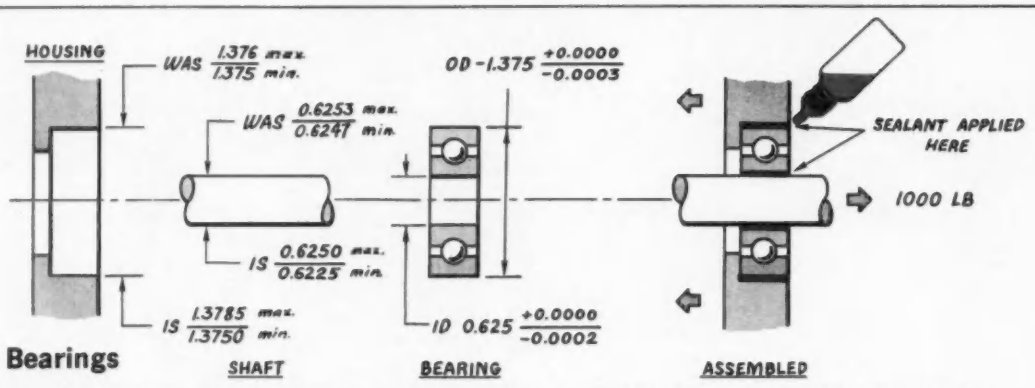
Check the complete line of IH engines now, and discover the extra selling advantages International power adds to your product. Call or write to International Harvester Co., Engine Sales Dept., Construction Equipment Division, Melrose Park, Ill.

INTERNATIONAL®
IH ENGINES

International Harvester Co.,
180 North Michigan Ave., Chicago 1, Ill.
A COMPLETE POWER PACKAGE

SIMPLIFY ASSEMBLY...
Retain parts on shafts with slip fit and Loctite

Designing with liquid LOCTITE eliminates press fits, shrink fits, broaching, knurling, keyways, set screws and pinning ... provides easier tolerances ... cuts rejects and rework.

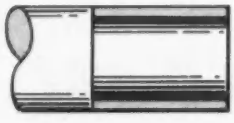


Bearings

LOCTITE Sealant replaced press fit, opening up tolerances .002 inch on shaft and housing. Rejects were cut from 8% to 1% and rework from 20% to 0! Bond to inner race withstands 1000 lbs. thrust ... equal to the best press fit. Slip fit with LOCTITE gives more uniform retention ... eliminates fretting damage due to loose "press fit" or bearing distortion resulting from tight press fit ... assures better shaft alignment. Easier tolerances speed assembly.

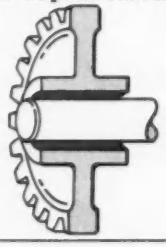
Hardened Sleeves

Eliminates shrink fit ... mounts hardened sleeve without pulling temper.



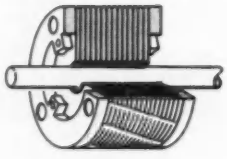
Gears and Pulleys

Eliminates broaching, knurling, shaft distortion. Easier gear replacement.



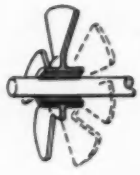
Rotors

Eliminates shaft distortion and resulting regrinding & straightening.



Fans

Eliminates set screws ... no amount of vibration will loosen part.



LOCTITE Sealant is easy to apply... simple to automate

LOCTITE is a one-component liquid with the unique property of converting to a tough plastic when confined between close fitting metal parts. It does not air dry. It does not require mixing with a catalyst and will not spoil on standing in a storage vessel. It comes fully prepared ... stores for years ... hardens only when treated parts are assembled. It forms a tough seal that resists heat, oil, water, all common solvents. Parts treated with LOCTITE can be disassembled by ordinary methods.

LOCTITE Kit No. 10-10

Contains 10 grades of Loctite Sealant specially put up to assist designers in determining proper grade and use of Loctite in product development and for general experimental work. By selection of proper grade, the designer can apply a predetermined amount of locking torque.

Write for literature and free sample capsule.

LOCTITE® SEALANT AMERICAN SEALANTS CO. 255 Woodbine St., Hartford 6, Conn.

Supplying DIAMOND T for 50 years has taught us a lot

The year is 1911. Diamond T Motor Truck Company has just built its first truck. Like most automotive manufacturers, they have included chassis parts by Clark.

As time marches on and both companies grow, they continue to work together. Today, they still do.

In 1960, for example, a number of Diamond T's most popular truck and tractor models have *as standard equipment* Clark four and five-speed *transmissions*.

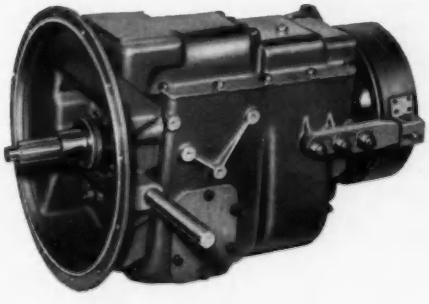
Latest development in the cooperation between the two companies is use of a Clark five-speed constant-mesh transmission as standard in several models of Diamond T's sensational new fiberglass Tilt-Cab line.

This transmission makes a major contribution to the Tilt-Cab tractor's over-all strength, light weight, long life, and safe handling. It is quiet-running, smooth, easy to operate, rugged and dependable. Diamond T engineers say they like Clark's fair price, high manufacturing quality, rapid and dependable delivery.

These same advantages are available to you. If you're a trucker, drive the new Diamond T fiberglass Tilt-Cab and see. If you're a manufacturer, ask us about other Clark transmissions for *your* truck, tractor, or bus.

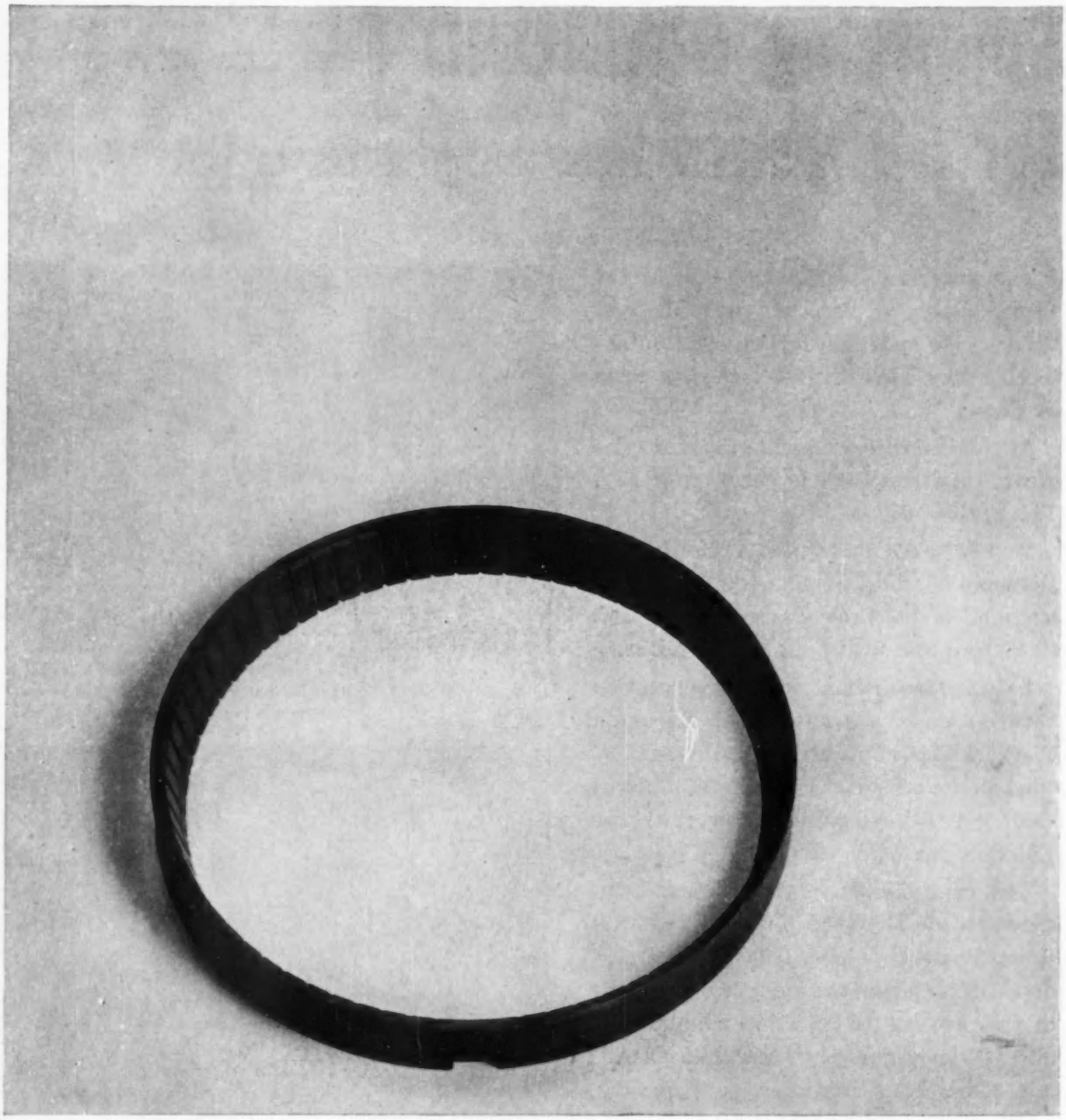
The first Diamond T truck. Built in 1911, it included a number of Clark chassis parts. Vehicle was in service over 20 years.

The latest Diamond T Tilt-Cab truck, a model 634CG. Just announced, its power train includes, as standard equipment, the Clark transmission shown below.



CLARK® EQUIPMENT

CLARK EQUIPMENT COMPANY
AUTOMOTIVE DIVISION
Buchanan 5, Michigan



YOU COULDN'T HAVE DONE THIS TWO YEARS AGO

They mold this reverse clutch cone from a phenolic reinforced with fibrous glass. Not just an ordinary phenolic, but one of the *newer* Durez phenolics . . . as unlike the plastics of the 1950's as are the cars of the two periods.

It weighs only 4 ounces, yet it can transmit the full power of a 1960 engine to a 2½-ton car.

This is but one of many new phenolics for new uses in tomorrow's vehicles. Others:

Phenolics for service wet on the inside and dry on the outside . . . *hose connectors*, for example.

A medium-impact phenolic for *distributor bowls* or to enclose accessory motors. Or for *air-cleaner bowls* that don't hum or rattle.

Reinforced phenolics for *oil-pump gears, transmission parts*—for *oil seals, bushings*—phenolics that outwear metal and cost less.

An important point to remember—

When you design for phenolics, you almost always get a better part at lower cost . . . even though lowered cost is not the immediate objective. Savings result from elimination of machining and other secondary operations.

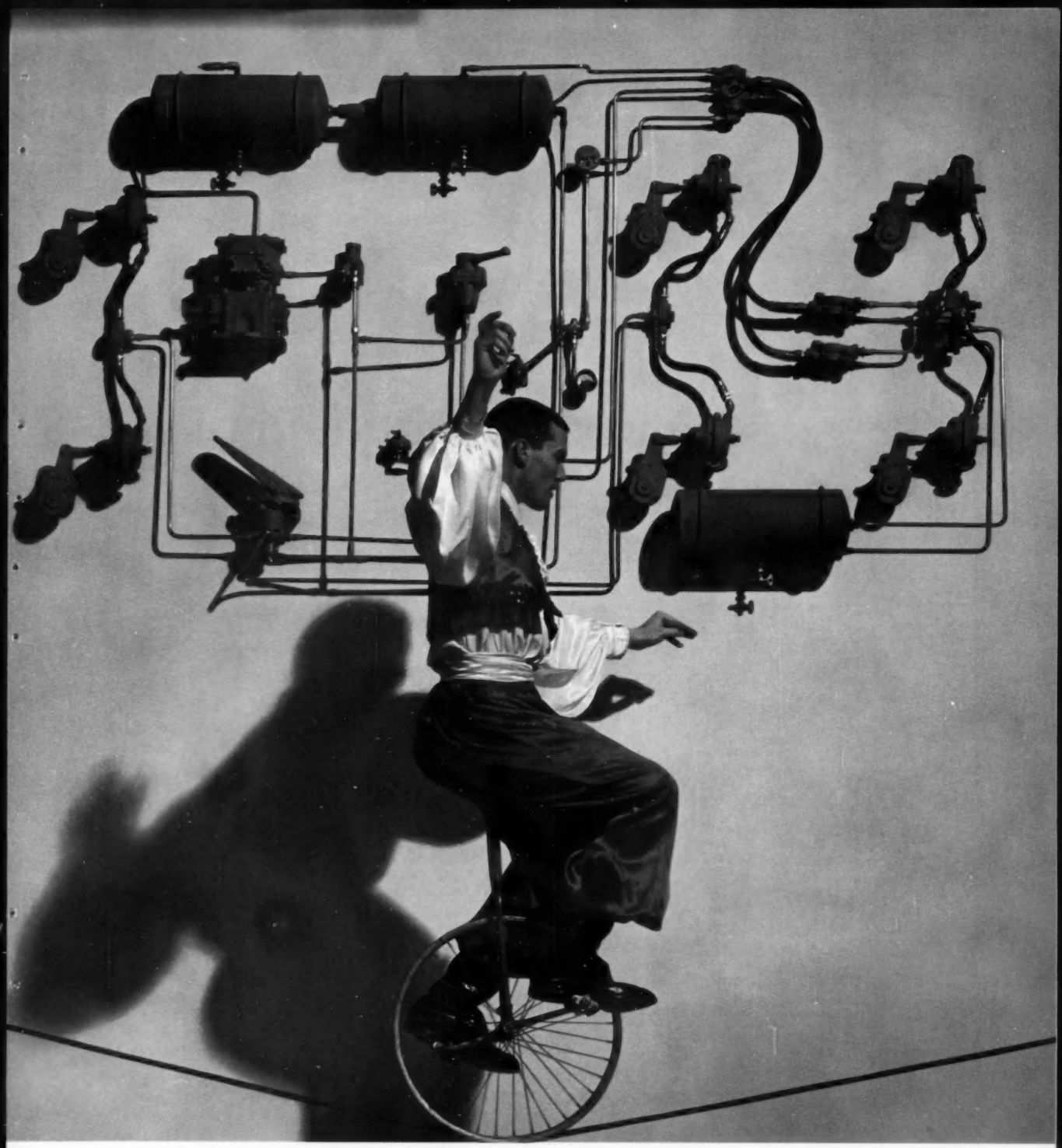
These newer, better phenolic formulations come in many combinations of properties to give you variety and versatility. More important, Durez can promise uniformity in these formulations, so that what works today will work tomorrow. Our Bulletin D400 has much more to say on these subjects. Write for it.

DUREZ PLASTICS DIVISION

8106 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS



"SYSTEMATIC" BALANCE . . . the unicyclist's ability to achieve perfect balance is essential to the mastery of his art. So, too, does an air brake system require perfect balance if it is to achieve maximum efficiency. Because all Bendix-Westinghouse Air Brake components are designed and engineered to work together as a system, they provide the completely balanced operation that means more long-range safety, economy, and dependability. That's why these systems are first choice of the nation's fleet operators and vehicle manufacturers. Good reason for you to make it Air Brakes by Bendix-Westinghouse.

SPECIFY COMPLETE AIR BRAKE SYSTEMS BY *Bendix-Westinghouse*

In nearly every field of business, there is one leader.

And he becomes the leader for a very logical reason.

Above everyone else, he offers more of what the customer wants. The leader in air brake systems—as it has been for 37 years—is Bendix-Westinghouse. You have made this so by your acceptance of the facts that Bendix-Westinghouse offers . . . ∞ MORE experience—over 2,200,000 compressors built since 1923. ∞ MORE research—millions of engineering dollars invested to produce new developments and contributions to safer, more dependable braking. ∞ MORE service outlets—a nation-wide network of 450 Bendix-Westinghouse distributors complementing thousands of truck dealers ready to serve truck operators wherever their rigs may be traveling. ∞ MORE complete line—in fact, the most complete line in the industry, custom-designed and tailored to individual job requirements. ∞ MORE acceptance—more trucks travel more miles with Bendix-Westinghouse Air Brakes than with all other air brakes combined. ∞ MORE economy—low operating cost through built-in long life and low replacement cost with our Repair Exchange Service. ∞ MORE satisfaction—because of top-quality system performance and longer service life. These are some of the reasons why, in air brake systems, it pays to specify the leader—Bendix-Westinghouse.

Bendix-Westinghouse

AUTOMOTIVE AIR BRAKE COMPANY

General offices and factory—Elyria, Ohio • Branches—Berkeley, Calif., and Oklahoma City, Okla.

"Wood Be" torsion suspension by Mather about 475 B. C.

LET MATHER SOLVE YOUR SUSPENSION PROBLEMS, TOO

Confucius's contemporary contraption really isn't confusing. It will work . . . its design is based on the proven principles of torsion suspension engineered by Mather.

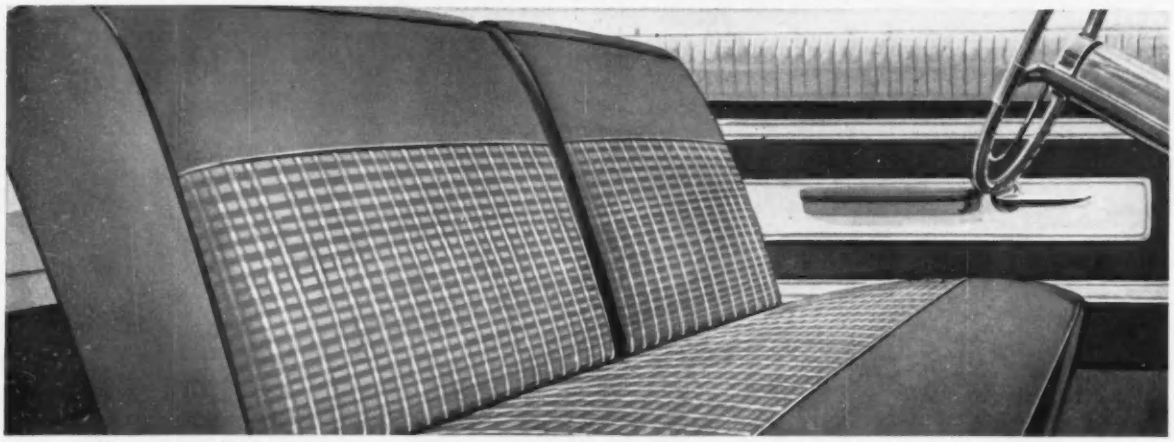
We have the experienced manpower, the research, design and manufacturing facilities to help you with your specific suspension needs.

Why not put our 50 years of experience to work. We'll welcome the chance.

MATHER

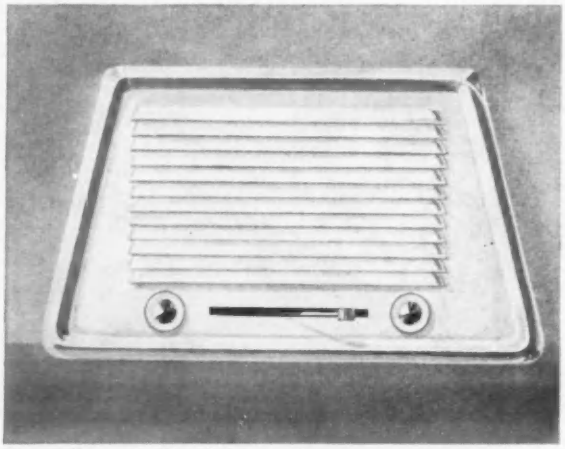
THE MATHER SPRING COMPANY

TOLEDO, OHIO



No Fugitive Plasticizers! Seat covers made of Escon polypropylene monofilaments do not emit fugitive plasticizers to fog windshields like many other synthetic upholsteries. In addition, these seat covers hold their shape as well as color...won't fade or bunch with repeated use. Other Escon properties include excellent impermeability to odor; good chemical and abrasion resistance; low density for more yardage per pound; and high tensile strength.

Sparks Cost Cuts! Escon exhibits high dielectric strength at all frequencies measured...provides a generous volume yield...allows finest detail in mold design. This makes Escon ideal for distributor caps, cable connectors and other under-the-hood parts.



Pure Punch Resistance! Some grades of Escon possess greater impact strength and hardness than many other thermoplastics...desirable properties in such items as air-conditioning grilles, heater grids, knobs and closures. Fast production cycles with Escon are another plus value.

Escon® POLYPROPYLENE SETS A NEW

Tomorrow's best-selling cars may well contain parts made of Escon. For example, as dashboard panels, its color matching qualities with high surface gloss and exact molding detail allow new design freedom—not possible with many other thermoplastics. Used for steering wheels, its impact strength and rigidity guard against cracking—a big safety feature! Steering wheels made of Escon won't absorb body odors either. Other suggested interior uses include kick plates, arm rests, sun visors and grilles—just to mention a few.

ENJAY PLASTICS

The automotive engineer will benefit greatly from Escon since it exhibits heat resistance up to 250°F., and shows resistance

STYLE FOR TOMORROW'S CARS

to oils, acids and solvents. This will make it ideal for many under-the-hood parts.

From every angle, Escon promises exceptional benefits. It offers manufacturers big economy because polypropylene's low density allows more pieces per pound. It offers car owners new comfort and safety features plus new beauty in design.

For technical assistance or to order Escon, contact the nearest Enjay office: (Home Office) 15 West 51st St., New York 19, N. Y. (Other Offices) Akron • Boston • Charlotte • Chicago • Detroit • Houston • Los Angeles • New Orleans • Tulsa • Toronto.

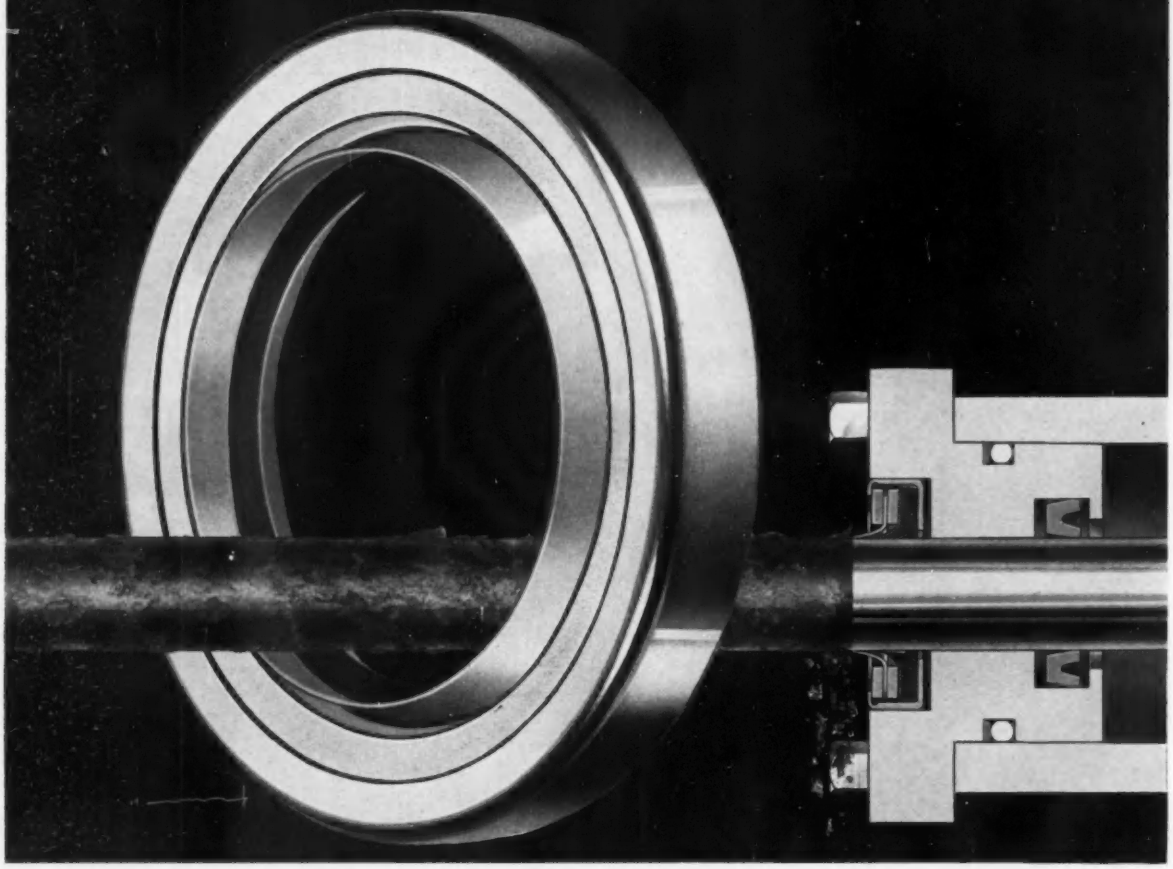
EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

A DIVISION OF HUMBLE OIL & REFINING COMPANY

ENJAY
PLASTICS

ANOTHER NEW PRODUCT DEVELOPMENT FROM C/R



New Wiper-Scraper Seal for Cylinders

Scrapes off ice, mud, tar – wipes off water, dust, other contaminants

Now, you can effectively exclude dirt and other contaminants from hydraulic cylinders under the most severe field conditions. One compact unit, the C/R SC Wiper-Scraper Seal does the job. Formerly, a separate rod scraper had to be installed in front of the ordinary wiper seal. The special machining necessary, plus the scraper ring, and retaining ring made this an expensive installation.

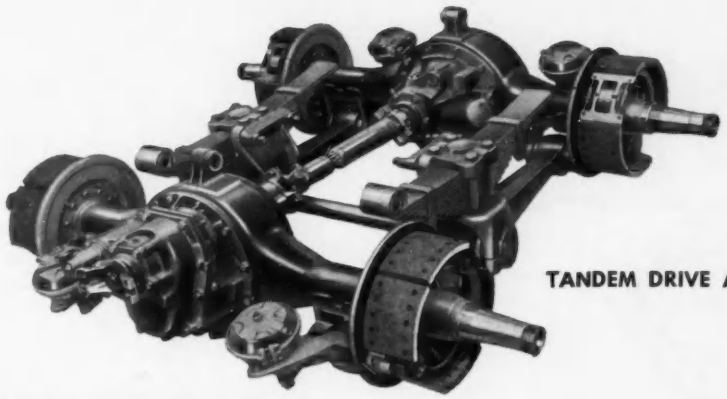
Chicago Rawhide's SC Wiper-Scraper Seal combines a spring brass scraper and synthetic rubber wiping member in one steel shell. The I.D. of the scraper is slightly under shaft size to provide a snug fit that will remove tar or frozen mud, but it has sufficient play within the shell to tolerate any off-center conditions of the rod such as caused by bearing "bore-slop." The cost is much lower than any other combination of scraper and wiper. "Design-in" cost is low, assembly simple. Most important is the performance contribution to the cylinder. The additional value of longer packing life and increased operating dependability with the SC Wiper-Scraper Seal will far outweigh the nominal cost.

For complete information, specifications and standard sizes, write for your copy of C/R's new Bulletin SC-100

CHICAGO RAWHIDE MANUFACTURING COMPANY

OIL SEAL DIVISION: 1243 **ELSTON AVENUE • CHICAGO 22, ILLINOIS**
Offices in 55 principal cities. See your telephone book.
In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario
Export Sales: Geon International Corp., Great Neck, New York
C/R Products: C/R Shaft & End Face Seals • Sirvene (synthetic rubber) molded pliable parts
Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears.

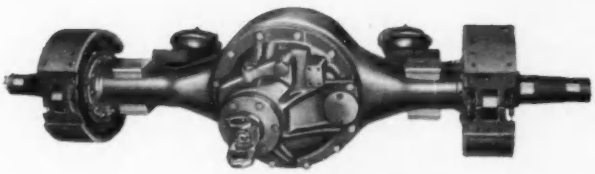
C/R



TANDEM DRIVE AXLES

"EATON AXLES"

The famous name that guarantees dependable performance and low hauling costs

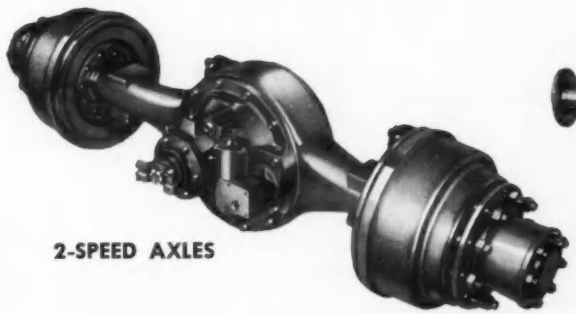


DOUBLE-REDUCTION AXLES

Through half a century, truck operators have learned that they can depend on Eaton Axles to deliver the kind of performance that keeps trucks on the road, cuts operating and maintenance costs, and adds to profit.

Eaton consistently leads the industry—particularly in the field of 2-Speed, Double-Reduction, and Tandem Drive units—with exclusive advancements which enable trucks to haul more legal payload, and add thousands of low-cost miles to both axle and vehicle life. The rugged stamina and efficiency of these Eaton-designed axles have been proven in billions of miles of operation in every type of service.

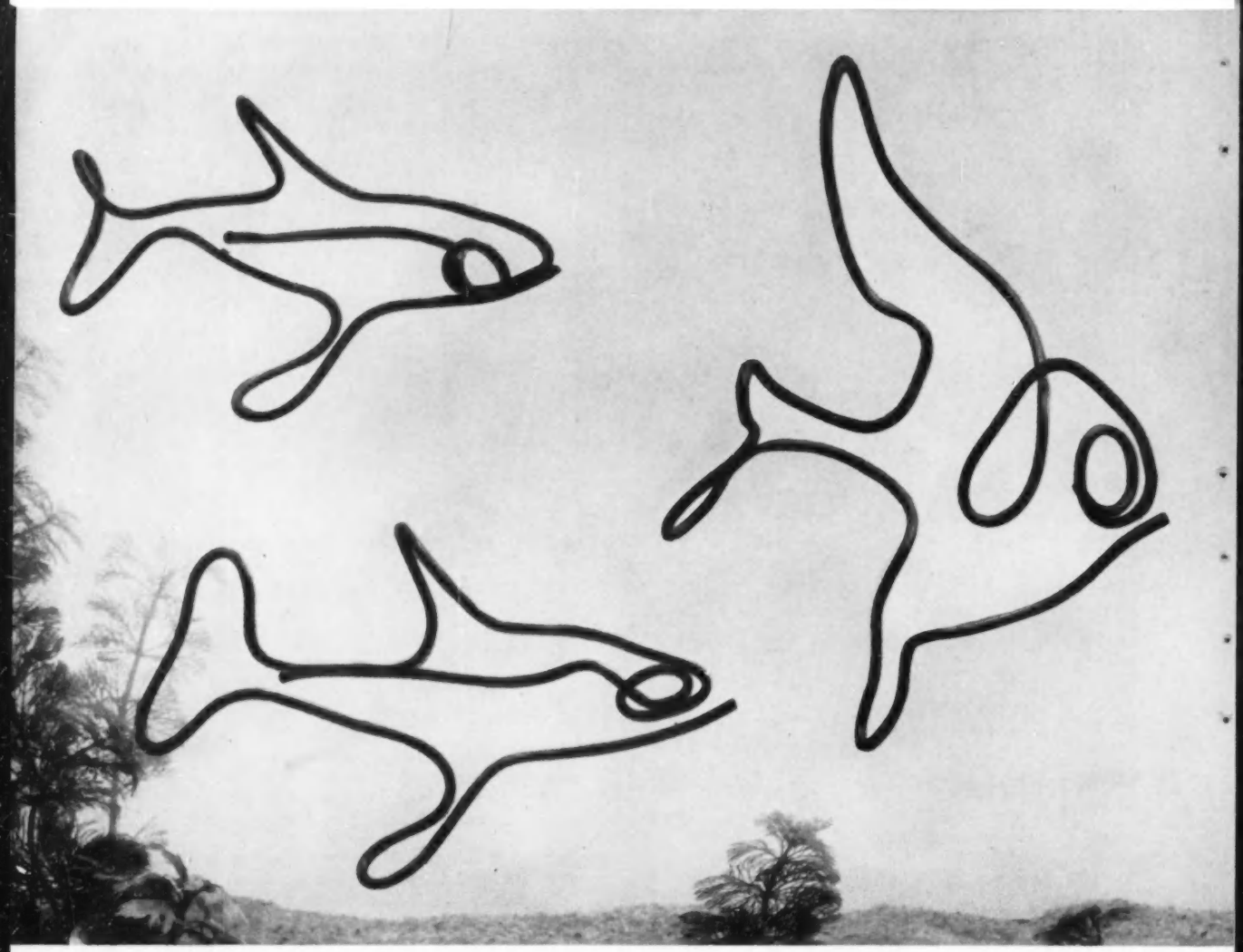
There's an Eaton Rear Axle best suited for your hauling requirement. Ask your truck dealer to help you specify the right one.



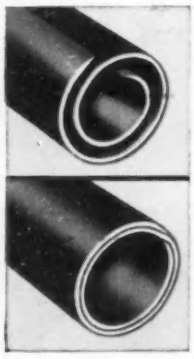
2-SPEED AXLES

SINGLE-REDUCTION AXLES

EATON — *AXLE DIVISION* —
MANUFACTURING COMPANY
CLEVELAND 10, OHIO



There's almost no limit to the things Bundy can mass-fabricate



Bundyweld is the only tubing double-walled from a single copper-plated *steel* strip, metallurgically bonded through 360° of wall contact for amazing strength, versatility.

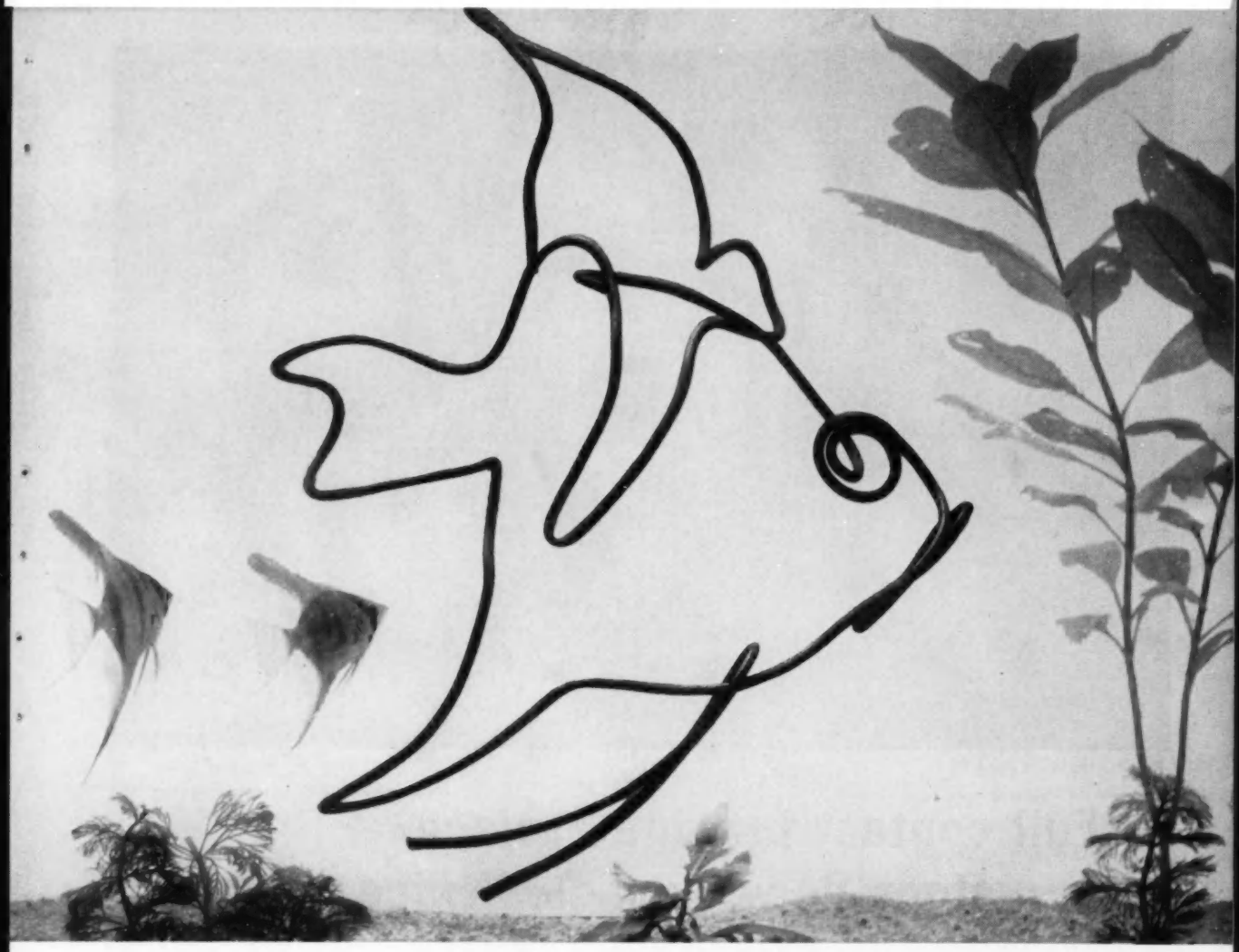
Bundyweld is lightweight, uniformly smooth, easily fabricated. It's remarkably resistant to vibration fatigue; has unusually high bursting strength. Sizes up to ⅝" O.D.

When it comes to mass-fabricating steel tubing into complex shapes, the folks at Bundy are specialists. Whether it's a push rod, a brake or fuel line—or a heat choke tube—chances are that Bundy can fabricate it better. Here are just a few reasons why:

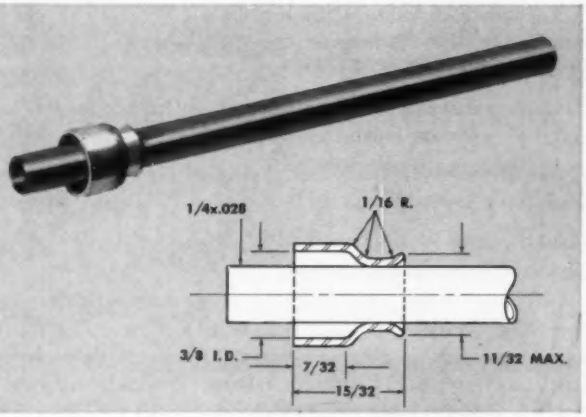
Bundyweld® Tubing is the original steel tubing *double-walled* from a single steel strip. Its high bursting strength and resistance to vibration have made it the safety standard of the automotive industry. Bundyweld is covered by Govt. Spec. MIL-T-3520, Type III.

Bundy designers will help you at any stage of product development. They may be able to suggest a new "twist" that'll cut your costs.

Bundy specialists will mass-fabricate parts to your specifications on Bundy-designed fixtures and machines. The unit-cost is low . . . the quality high. Got a tubing problem? Better see Bundy *first!* Phone, write or wire Bundy Tubing Company, Detroit 14, Michigan.



Bundyweld tubing is versatile, as demonstrated by this Bundyweld collar for an automatic heat choke tube. And Bundy is geared to give you mass-fabrication savings, too. Can Bundy solve a production bottleneck for you?



There's no real substitute for

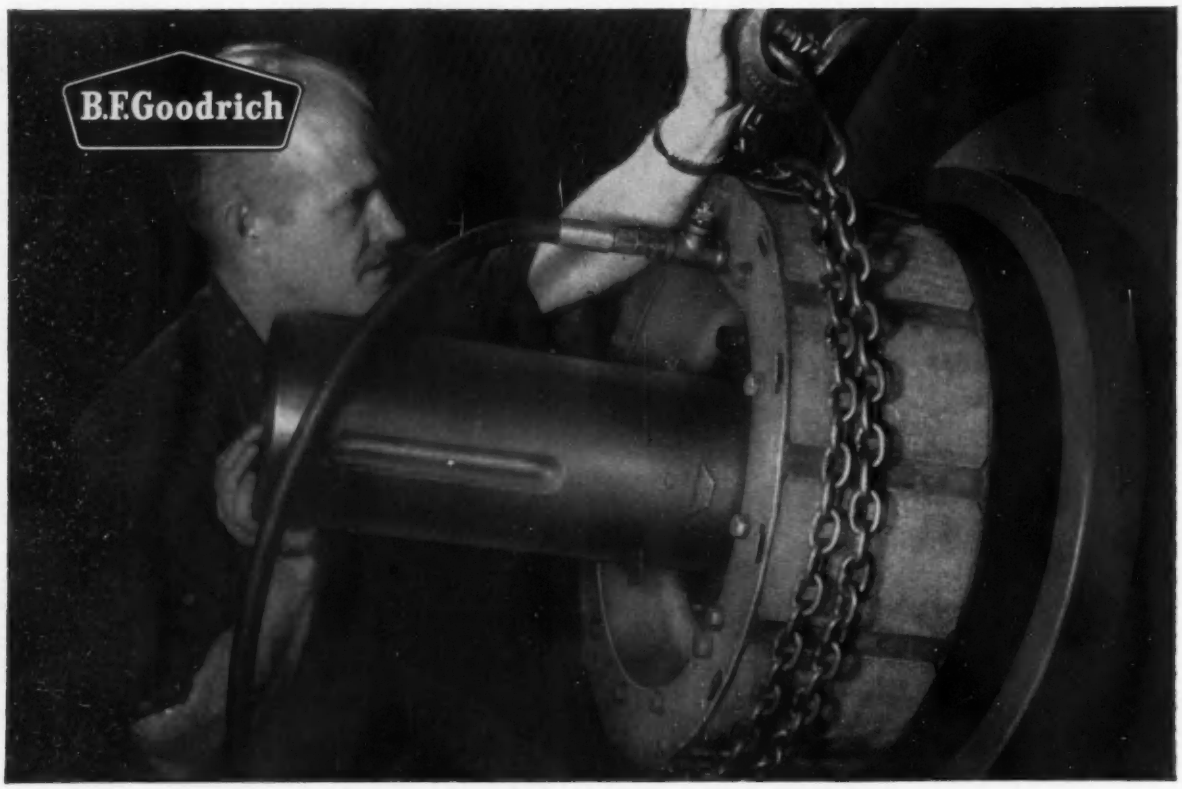
BUNDYWELD® TUBING

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING • AFFILIATED PLANTS IN AUSTRALIA, BRAZIL, ENGLAND, FRANCE, GERMANY, AND ITALY

BUNDY TUBING COMPANY • DETROIT 14, MICH. • WINCHESTER, KY. • HOMETOWN, PA.

Sizes up to ⅜" O.D.

write or wire Bundy Tubing Company, Detroit 14, Michigan.



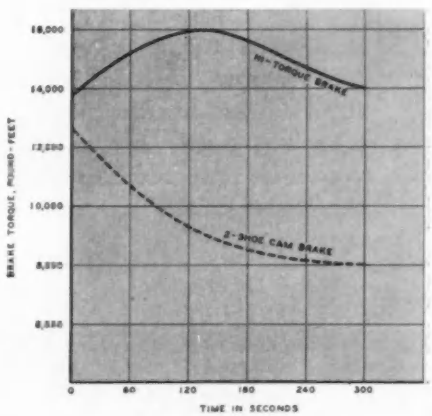
Full contact braking surface stops heavy vehicles twice as fast

Today's heavyweight vehicles need braking power to suit—and you get it with B. F. Goodrich Hi-Torque brakes. With these brakes, each of the shoes is forced by hydraulic power against the inside of the brake drum to provide *full-circle* braking action. Here are the advantages:

- Stopping distance cut approximately in half compared to conventional two-shoe brakes tested on identical vehicles and loads.
- Increased safety and controllability of the vehicle, permitting faster, more profitable use by the operator . . . shorter work cycles.
- Brake torque is maintained with minimum "fading" because of the non-energized design.

Hi-Torque brakes adjust themselves automatically, need no lubrication. Available in sizes from 17¼" x 4" to 26" x 7". Brakes can be operated by either air-over-hydraulic or direct-hydraulic actuation. Write B. F. Goodrich Aviation Products, a division of *The B. F. Goodrich Company, Dept. SJ-6, Troy, Ohio.*

DOUBLE THE TORQUE—Dynamometer test made at constant speed 53 rpm, constant pressure conditions, brakes applied on 15-second cycles. Test duplicates operating conditions of heavy vehicle on long downgrade.



B.F.Goodrich Hi-Torque brakes

REICHHOLD PRODUCTS	TYPE	FOUNDRY PROCESS	OUTSTANDING FEATURES
FOUNDREZ 7100 Series	Liquid Resin	CONVENTIONAL CORES	High Hot Strength High Baked Strength
FOUNDREZ 7600 Series	Liquid Resin		Rapid Collapsibility Fast Bake
CO-RELEES 7300 Series	Oil		Excellent Sand Conditioning
coRCIment 7900 Series	Oil		Broad Baking Range Excellent Workability
FOUNDREZ 7150 Series	Liquid Resin	SHELL MOLDS AND CORES	Unusual Stability
FOUNDREZ 7500 Series	Granulated & Powdered Resin		High Tensile Strength Low Gas
COROVIT 7200 Series	Oil & Powdered Accelerator	SELF-CURING	Controlled Curing
REICOTE 7800 Series	Solvent	SAND COATING	Exceptional Coating Speed

For further information regarding any of these materials, write our Foundry Products Division at White Plains

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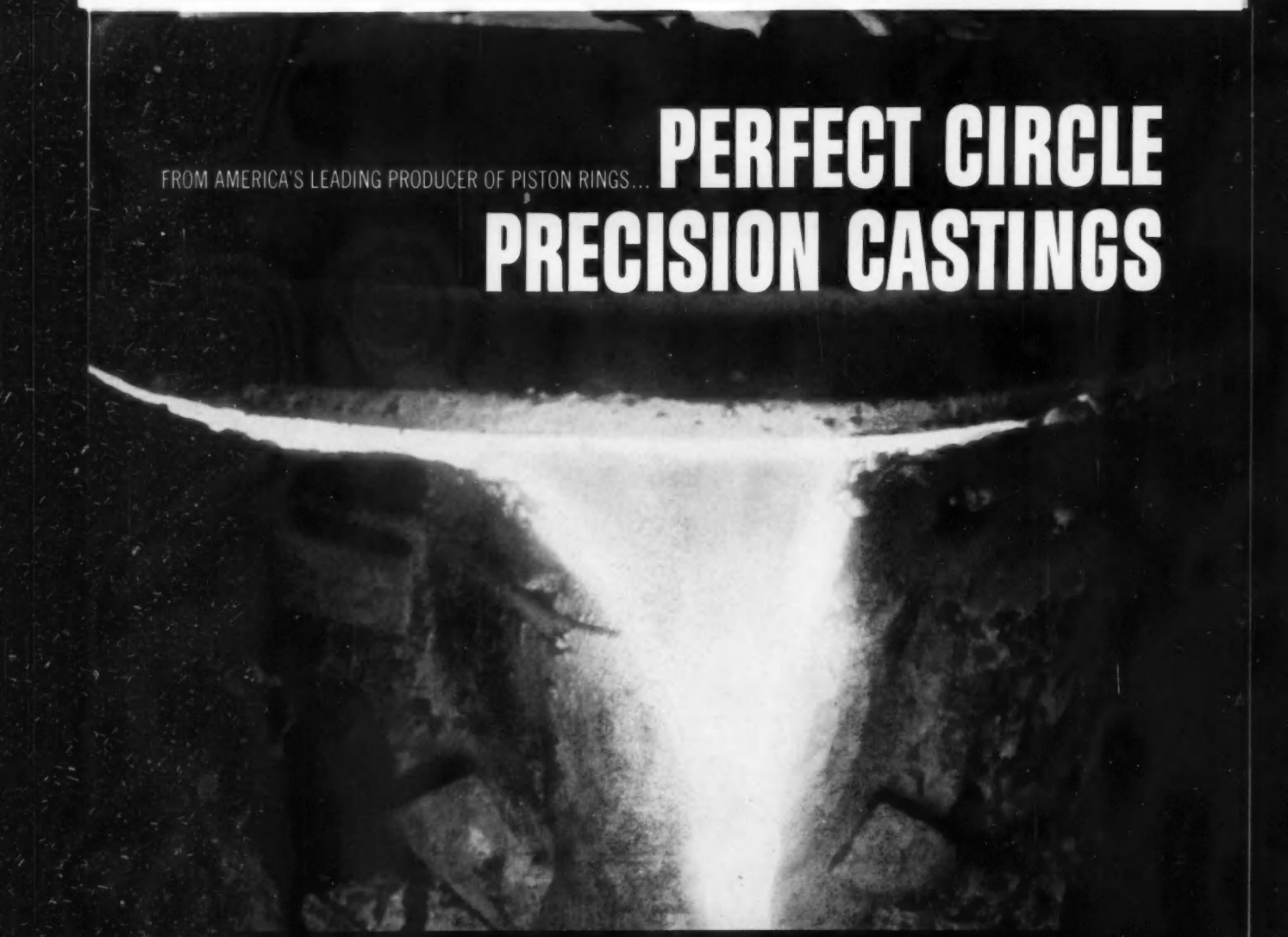
REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N.Y.

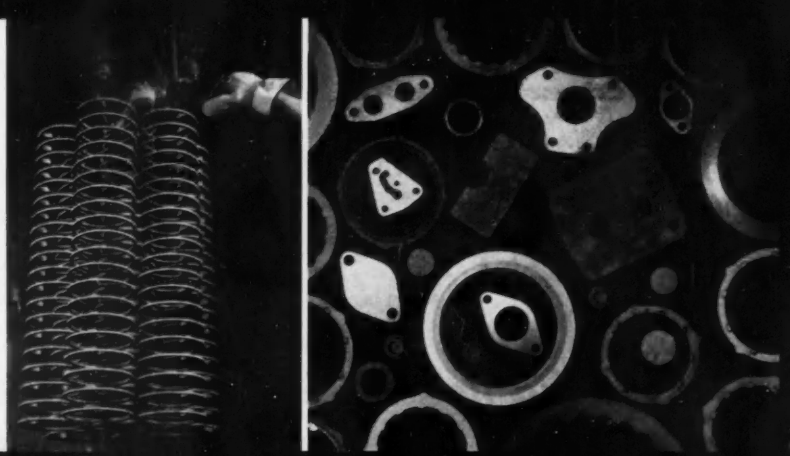
FROM AMERICA'S LEADING PRODUCER OF PISTON RINGS...

PERFECT CIRCLE PRECISION CASTINGS



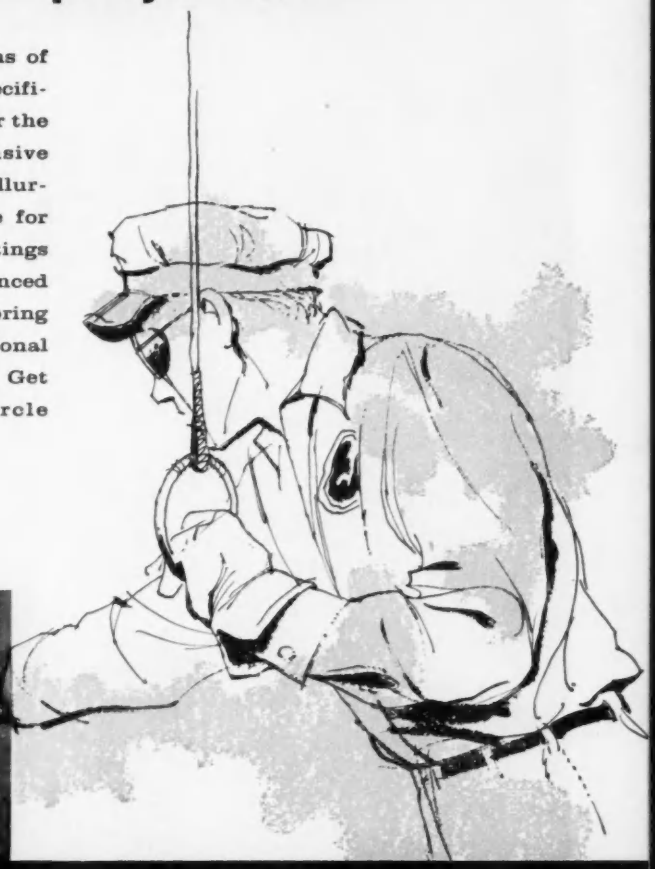
STACK-MOLD CASTING

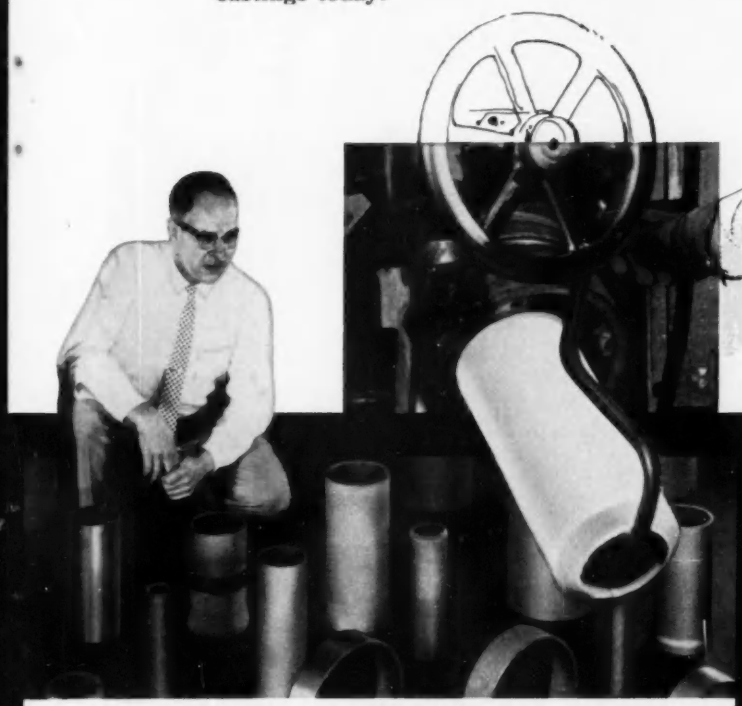
Molds of carefully-controlled green sand are made from the pattern plate, and stacked for pouring. In the example shown above after shake-out, the castings are 6-up in a stack 20 molds deep. Typical castings produced by this Perfect Circle process include piston rings, thrust plates, valve lifter facings and piston groove inserts.



Mass-produced to the highest quality standards

Every year, Perfect Circle produces millions of piston rings—all made to the exacting specifications that have set precision standards for the industry. Now, as the result of extensive expansion, the modern facilities and metallurgical skills of Perfect Circle are available for volume production of superior gray-iron castings to your specifications. And, through its advanced production techniques, Perfect Circle can bring you the finest metallurgical and dimensional precision at important cost advantages. Get complete information on Perfect Circle castings today!





WHIRLCAST CYLINDRICAL FORMS

Hot metal is poured into permanent molds, and then spun at high speeds to create machineable cylindrical gray-iron castings of uniform dimension and hardness, with microstructure controlled to exacting specifications. PC Whirlcast products are offered in a wide range of sizes and materials, all precision-made for fast, economical machining with minimum stock removal.

MAIL THIS COUPON TODAY FOR COMPLETE INFORMATION

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CASTINGS DIVISION, DEPT. SJ-6
HAGERSTOWN, INDIANA

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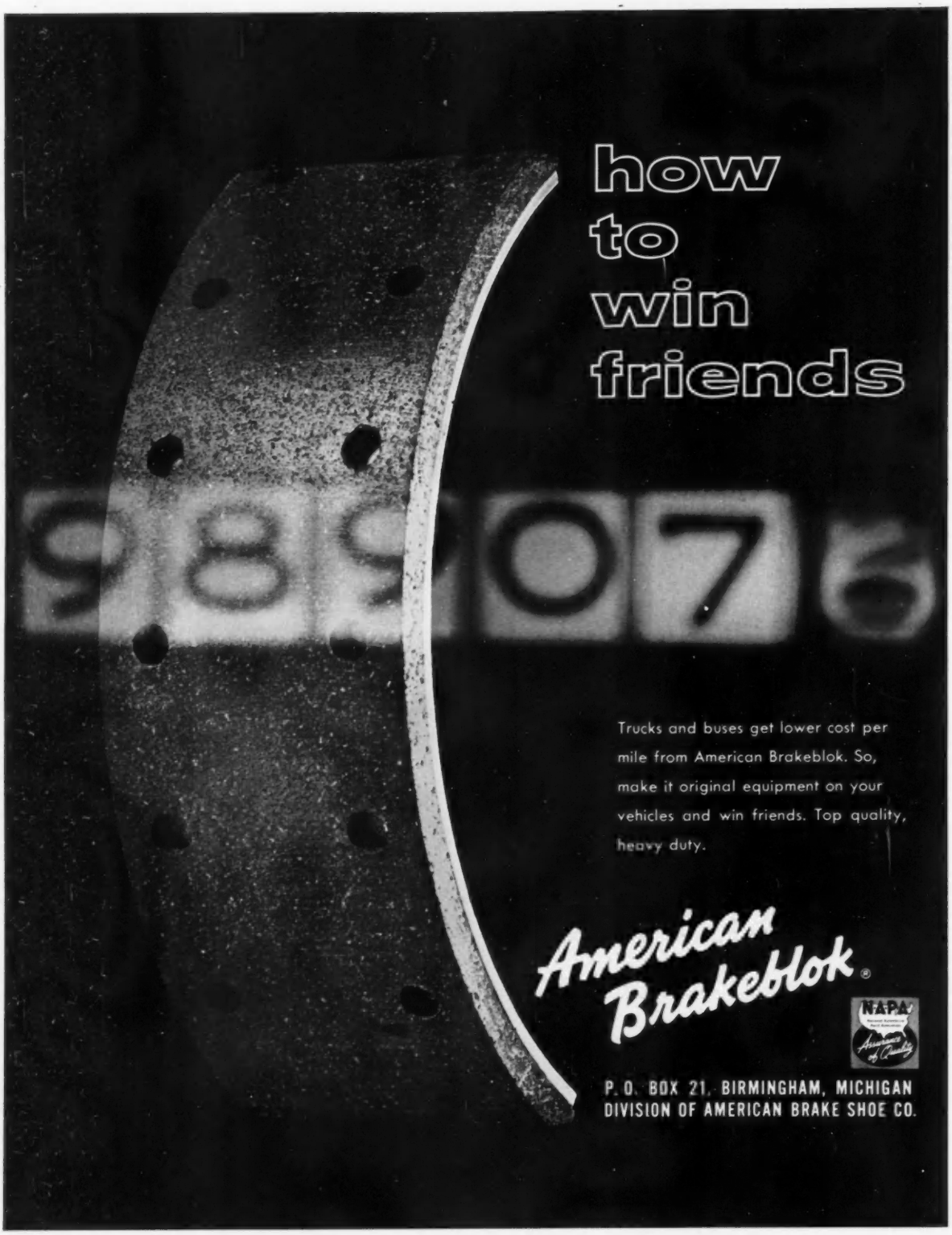
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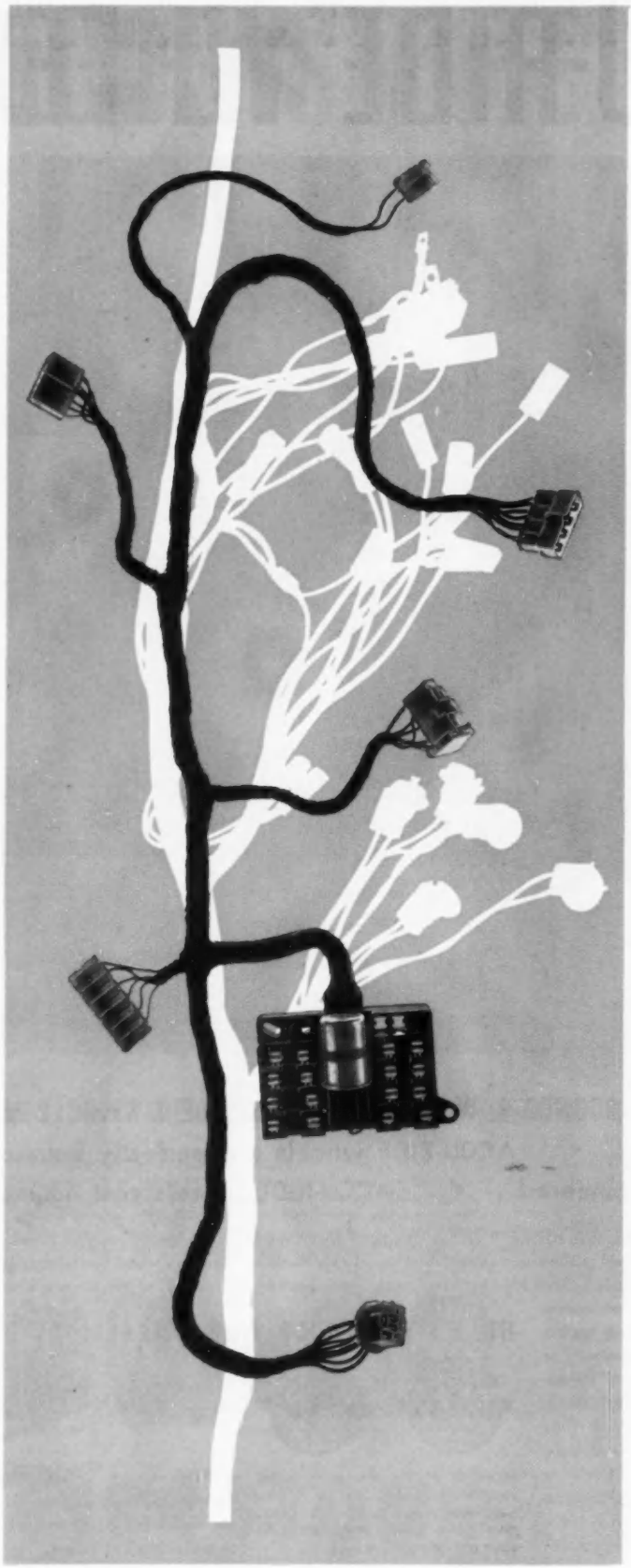

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Packard Electric engineers strive continually to make their products less expensive and faster to install. Now they have made it possible for the already efficient automotive wiring harness to become an even more complete sub-assembly. • For example, the dome light of the Corvair is attached to the wiring harness at Packard and shipped ready to snap into the roof of the car along with the wiring. Single terminals are replaced by "Snap Fast" multiple connectors, fuse blocks and other cost-saving components. • If your present wiring harnesses do not include these advantages ask Packard Electric engineers to help work out modern wiring systems for you. Packard Electric, the world's largest producer of automotive wiring systems, has sales and engineering offices in Detroit and Chicago.

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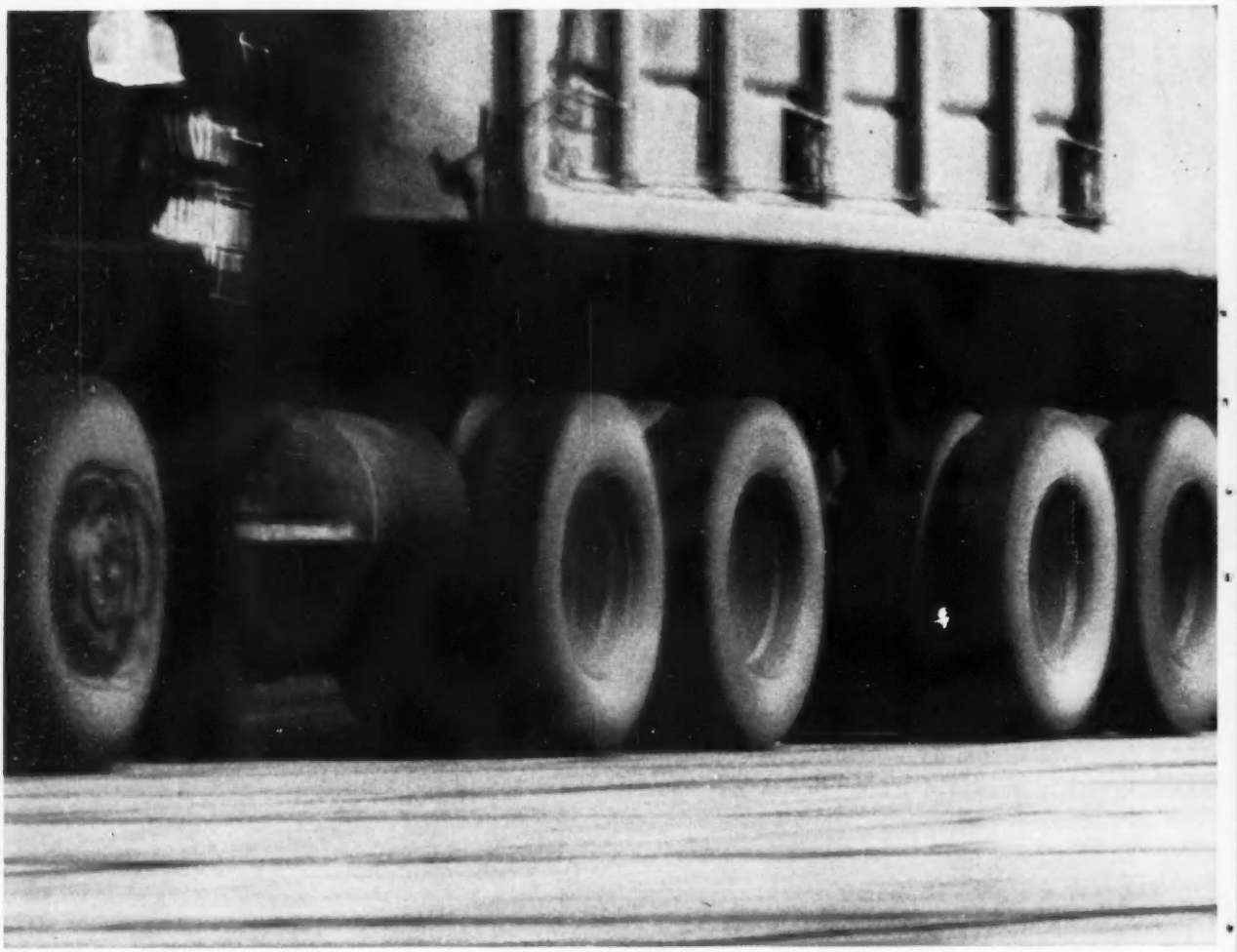
Warren, Ohio — GM GENERAL MOTORS

"Live Wire" division of General Motors

NEW ACCU-RIDE* WHEEL



ACCU-RIDE PRECISION BEATS WHEEL BOUNCE & WOBBLE, EXTENDS TIRE & VEHICLE LIFE

ACCU-RIDE wheels are truly round • ACCU-RIDE wheels are perfectly balanced
ACCU-RIDE wheels are precision-engineered • ACCU-RIDE wheels cost no more

MEET THE WORLDS' FIRST MASS-PRODUCED PRECISION STEEL WHEEL. It's years ahead and it's made possible only by Firestone's advanced metal-working technology. The Accu-Ride disc wheel is the truest-rolling steel wheel ever made and the *only* wheel specially designed to withstand today's high-speed, heavy-load operating conditions. Accu-Ride precision engineering permits a maximum of vehicle and tire life. That's because Accu-Ride wheels are spin-formed for maximum control of dimensions, improvement of strength characteristics and perfect balance. Its continuous Thruweld provides a joint twice as strong as any other fastening of a rim to a disc. Exclusive Firestone Perma-Plate finish beats corrosion. And Accu-Ride wheels are available *at no extra cost* for every truck, bus and truck-trailer on the road. They are performance-proved by eight years and 150 million miles of tests. For further information on Firestone Accu-Ride wheels—or Firestone Precision Rims—write, wire or call the Firestone Technical Service Man at Firestone Steel Products Co., Department 45(7) Akron 1, Ohio.

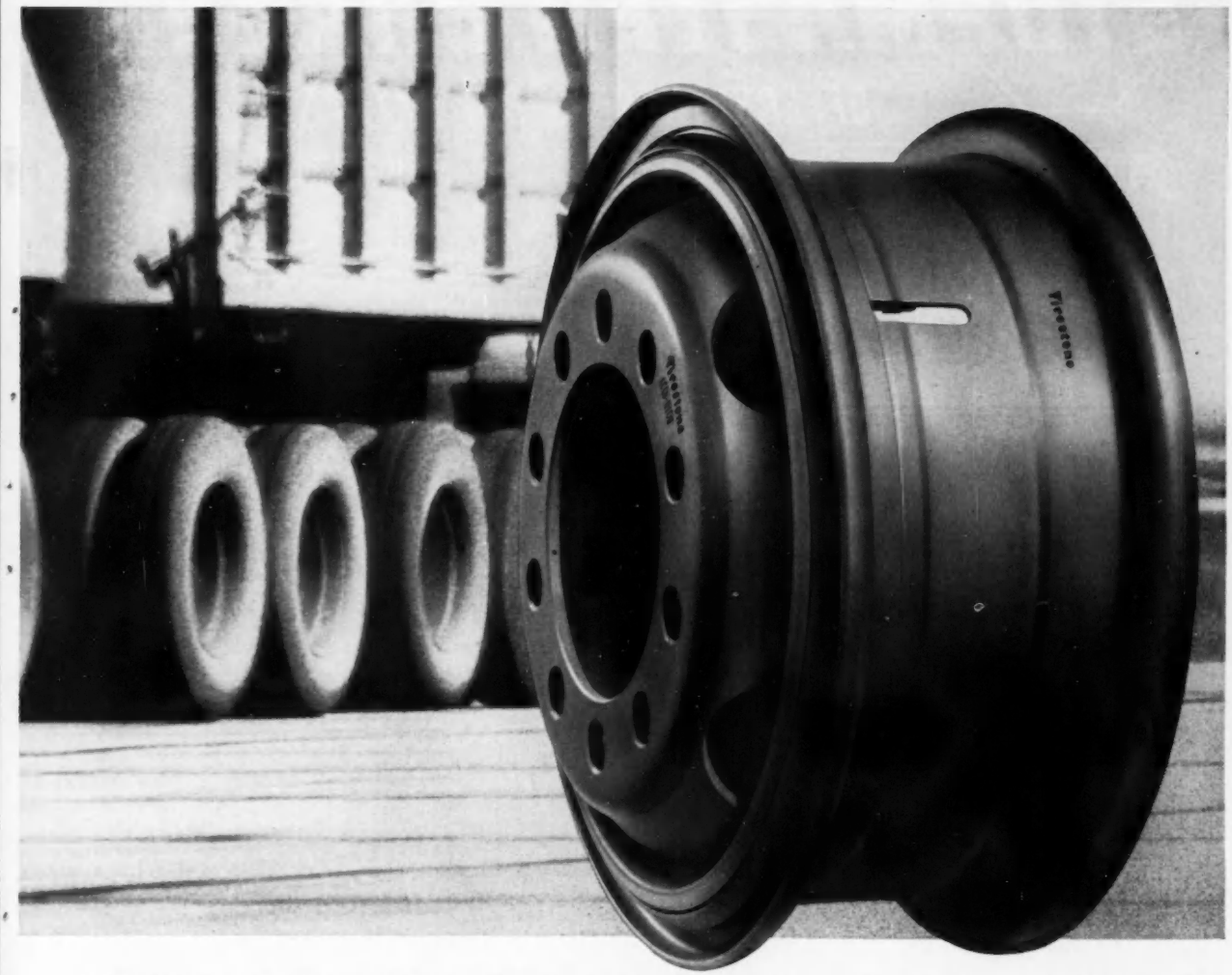
*Firestone Trademark

HERE'S HOW ACCU-RIDE WHEELS PAY OFF

Accu-Ride wheels minimize radial run-out, leap and bounce, eliminate tire cupping, reduce wear, give three times smoother ride than out-of-round wheels.

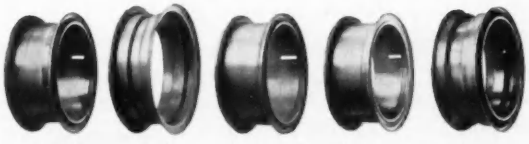
Accu-Ride wheels greatly reduce tire-wearing wobble (from lateral run-out) over out-of-line wheels to make tires last longer.

BOOSTS TIRE MILEAGE!



FIRESTONE TIRE-TAILORED PRECISION-CORRECT RIMS MEAN EXTRA TIRE MILES, TOO!

Firestone's precision-correct, compression-fit truck and bus rims give complete support to tires, put full tread width on pavement for maximum traction, longer tread life, lower cost-per-mile performance. They are tailored to make tires fit better and last longer and are available on Accu-Ride wheels for both tube-type and tubeless tires. All Firestone rims are protected with exclusive corrosion-proof Firestone Perma-Plate finish.



5° Commander RH5° FL5° Challenger N5° Challenger 15° Drop-Center

5° Commander: World's most popular 3-piece rim. Stress-tested, fleet-proved. Full bead support, wide base design, continuous side ring, full offset.

RH5°: 2-piece disc wheel rim. Continuous side ring, full bead support and wide base eliminate rocking, reduce flexing for longer tire life.

FL5° Challenger: Full-offset, work-weight, tube-type rim. Eliminates bead chafing, rocking. Will do heavy work usually expected from heavier rims.

N5° Challenger: Lightest weight tube-type rim made. Weighs up to 10 lbs. less than comparable rim. 5° bead support reduces tire rocking, sidewall flexing.

15° Drop-Center: 1-piece official design for tubeless truck tires. Open-face mounting ring stops wobble, 15° bead seat on rim and tire gives true air seal.

Firestone

STEEL PRODUCTS COMPANY
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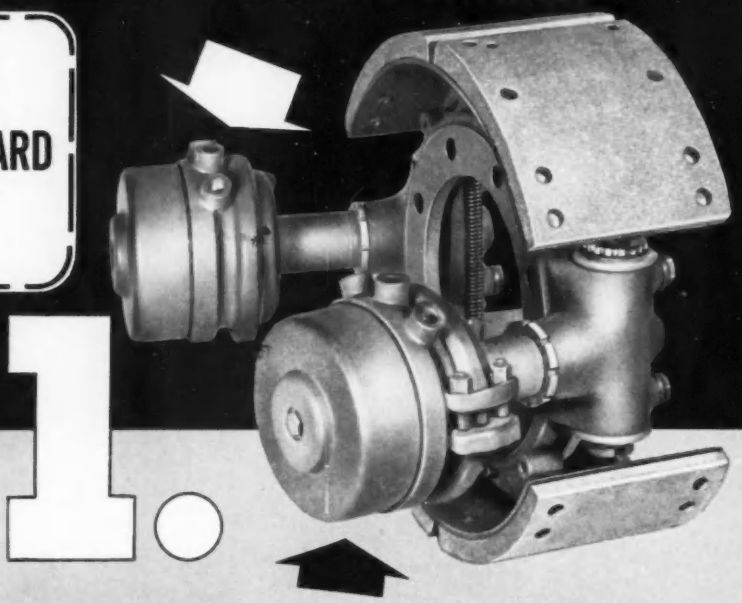
NEW STOPMASTER BRAKE

OFFERS THESE 3 BIG EXTRAS!

ANOTHER ROCKWELL-STANDARD FIRST!



Proven the most advanced brake design in 30 years . . .

Outstanding improvements, such as a new balanced shoe actuation principle and 15" diameter, have made the Stopmaster Brake the industry's most efficient and dependable brake. Now Rockwell-Standard also offers you these three important extras in the Stopmaster:

1 **"Fail-Safe" Units** . . . now available for air actuated Stopmaster Brakes.

- Prevents runaway vehicles due to loss of air, when in operation or parked.
- Positive mechanical operation . . . can be installed to operate from dash control valve or automatically, or both ways if desired.
- Lightweight and compact . . . no installation problems, no cables or special brackets required.
- Provides mechanical parking brake . . . eliminates need for prop-shaft brake.
- Brakes easily released . . . without air pressure.

2 **Automatic Brake Adjustment** . . . available on all Stopmaster Brake sizes for trucks, trailers, and off-highway vehicles.

- Eliminates periodic manual adjustment.
- Cuts expensive maintenance costs.
- Brake maintains proper adjustment during entire lining life.
- Safer operation at all times.

3 **Lubrication Eliminated.** All actuating parts are sealed in lubricant. Standard on all models.

- Prevents oil-soaked linings due to over lubricating.
- Moving parts last longer.
- Reduces friction.
- Completely sealed unit reduces effect of elements.

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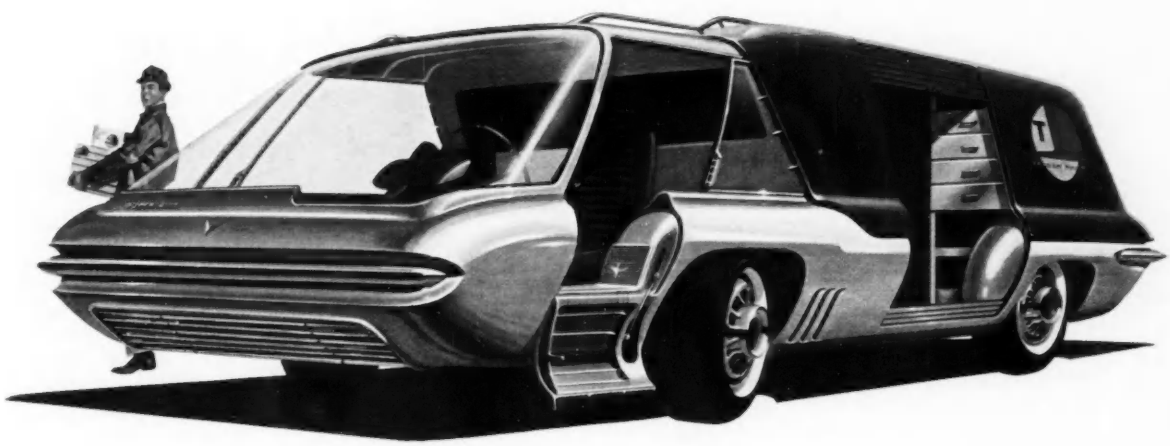

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McLOUTH STAINLESS STEEL

R/M engineers helped marine transmission manufacturers solve clutch problems for this 55-ft. Chris-Craft Constellation. Twin engines develop up to 550 hp, provide speeds to 23 mph; equipped with newly designed hydraulic aluminum marine transmissions with R/M sintered bronze clutch material.

Photo courtesy Chris-Craft

How Raybestos-Manhattan helped design clutch for new marine transmission

"The extensive friction material knowledge and experience of R/M engineers save us time and money when we are working on a new design for a clutch or friction part," says Carl Benson, assistant manager and chief engineer, Paragon Gear Works, Taunton, Mass.

Solve problems on spot

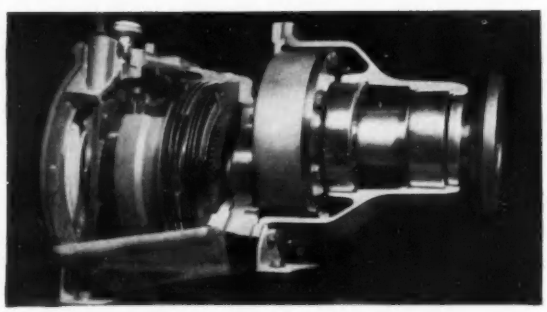
"In developing our new 'H-A' hydraulic aluminum transmission, we took an R/M engineer right with us to our customer's engine plant in Michigan. We solved our clutch problems on the spot.

"Our customers appreciate this extra engineering service we can offer them through R/M. Wherever we are we know we can pick up the phone and have the nearest R/M engineer come to us. We get this extra service, yet prices are competitive; quality is uniformly high."

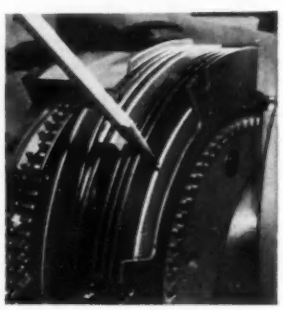
Save time, money

You may also be able to save time and money by calling on experienced R/M engineers to help solve your friction problems. You can depend on sound, unbiased counsel on the material best suited for your application—for only *R/M manufactures all types of friction materials!* An R/M sales engineer can be at your desk within 24 hours.

Send now for your free copy of Bulletin No. 501—packed with helpful engineering information on friction materials.



Advanced-design Paragon "H-A" hydraulic aluminum transmission for Chris-Craft 430 engine which develops 275 hp at 4000 rpm. Clutch is self-compensating; no adjustment ever.



Pencil points to R/M sintered metal clutch facing. .015 in. of sintered bronze on .070 in. steel plate. Has a high coefficient of friction in presence of oil; strength to withstand 4000 rpm; precision operation within narrow clearances of .007 to .010 in.

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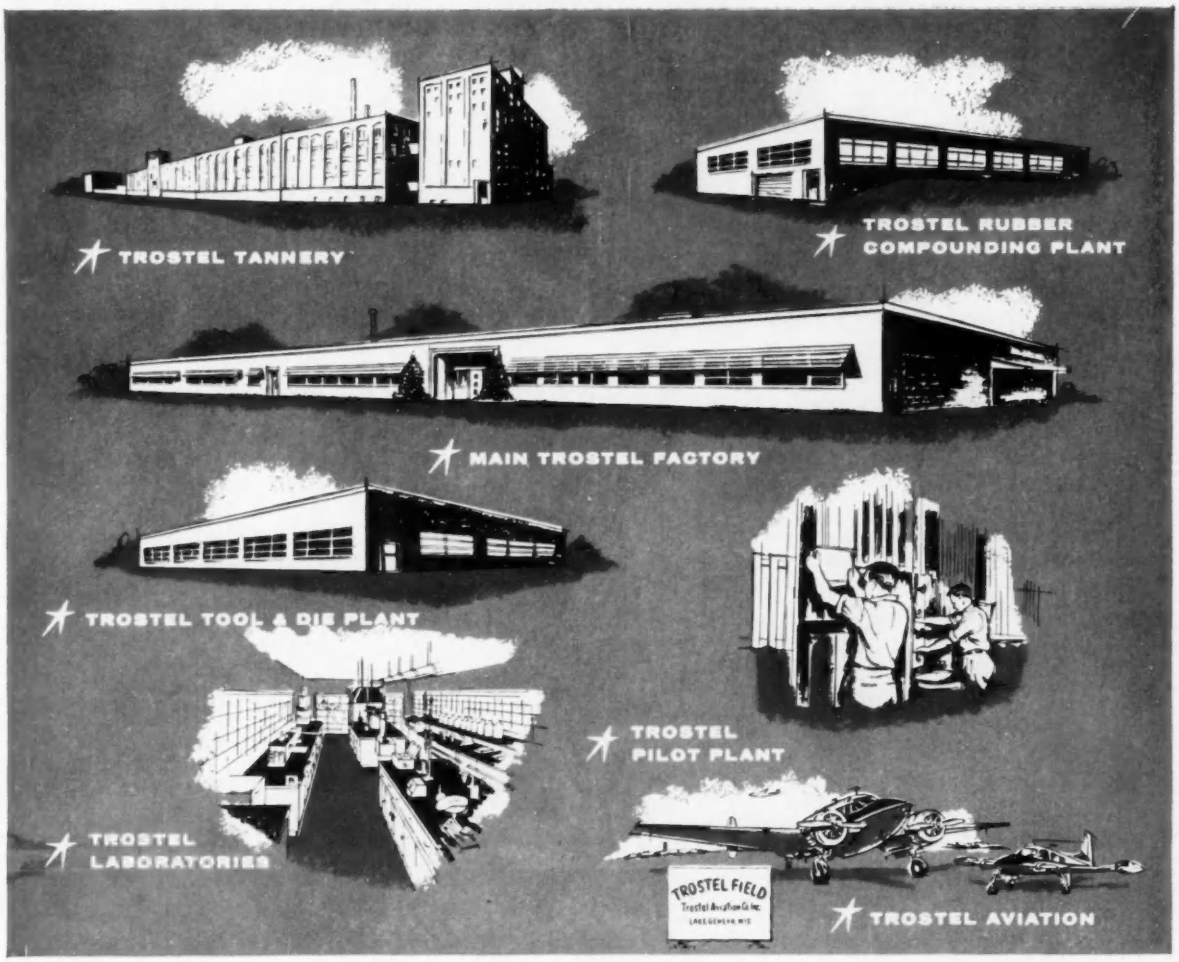

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new LONG LIFE PISTON

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G and E Wire Insert Piston before machining (left) and after ring grooves are cut (right) showing how the steel wire forms a tough wear-resistant surface on both faces of top ring groove. The ferrous plug molded in the head (for diesel pistons) prevents burning through head and lengthens diesel piston life!

G and E WIRE INSERT PISTONS

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Low cost per mile

★ Amazing increase
in piston life

★ Maintains
new engine power
and performance

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This Gillett & Eaton exclusive steel wire insert cuts top ring groove wear and greatly increases mileage between overhauls.

You get longer piston wear at lower cost because G & E Wire Insert Pistons have a pre-shaped steel wire cast right in the piston wall where the top ring is located. When the grooves are machined, this tough wire is cut, exposing the closely spaced hard surfaced bearing points on top and bottom faces of the groove.

CAST IRON

ALUMINUM

GET THE G AND E WIRE INSERT STORY—it will save piston money, maintenance costs, and cut operating costs.

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ESTABLISHED 1868

BLOOD BROTHERS jointed steering assembly guides giant LeTourneau-Westinghouse coal hauler!

No matter how large the equipment you design, there's a Blood Brothers steering or jointed driving assembly big enough to do the job. One example of the use of Blood Brothers components on large equipment is the L6S Steering Assembly on the LeTourneau-Westinghouse Haulpak Coal Hauler.

This mammoth, highly maneuverable "mountain mover" is a bottom-dump 450 h.p. diesel unit that weighs 37 tons. Yet it carries 2½ *times* its own weight in payload, or the equivalent capacity of over one and one-half standard 50-ton railroad cars!

Rockwell-Standard's Universal Joint Division offers you a wide range of specialized engineering experience—involving everything from manual steering assemblies . . . to power take-off drives . . . to heavy-duty propeller shafts. Whatever size and type equipment you manufacture, Rockwell-Standard can save you time, money – help you achieve higher standards of performance. Let us prove it—on your project!

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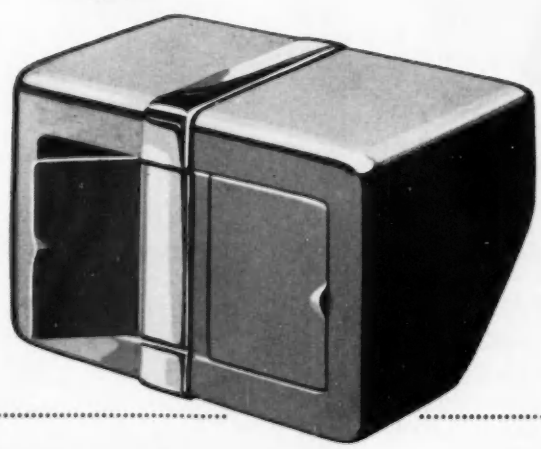

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Higher Education for Computers

"Let's put the computer in at the start of a problem, rather than just having it buzz through the computations."

This is the approach being taken by computer specialists at the General Motors Research Laboratories as they explore ways of giving large-scale digital computers a greater role in the solution of problems. The object is to "teach" computers to apply the same rules men use in formulating, analyzing, and solving questions of modern science and engineering.

A recent outgrowth of this work is DYANA, GM Research's new automatic analysis and programming system. DYANA is one of the first computer systems to "understand" declarative statements. For a large class of dynamic problems, the engineer can simply describe his physical system to the computer. The computer figures out how to handle it.

For the solution, DYANA automatically directs the computer to prepare a mathematical model of the system, to write its own program for solving the model, then to execute the program and compute the desired answers.

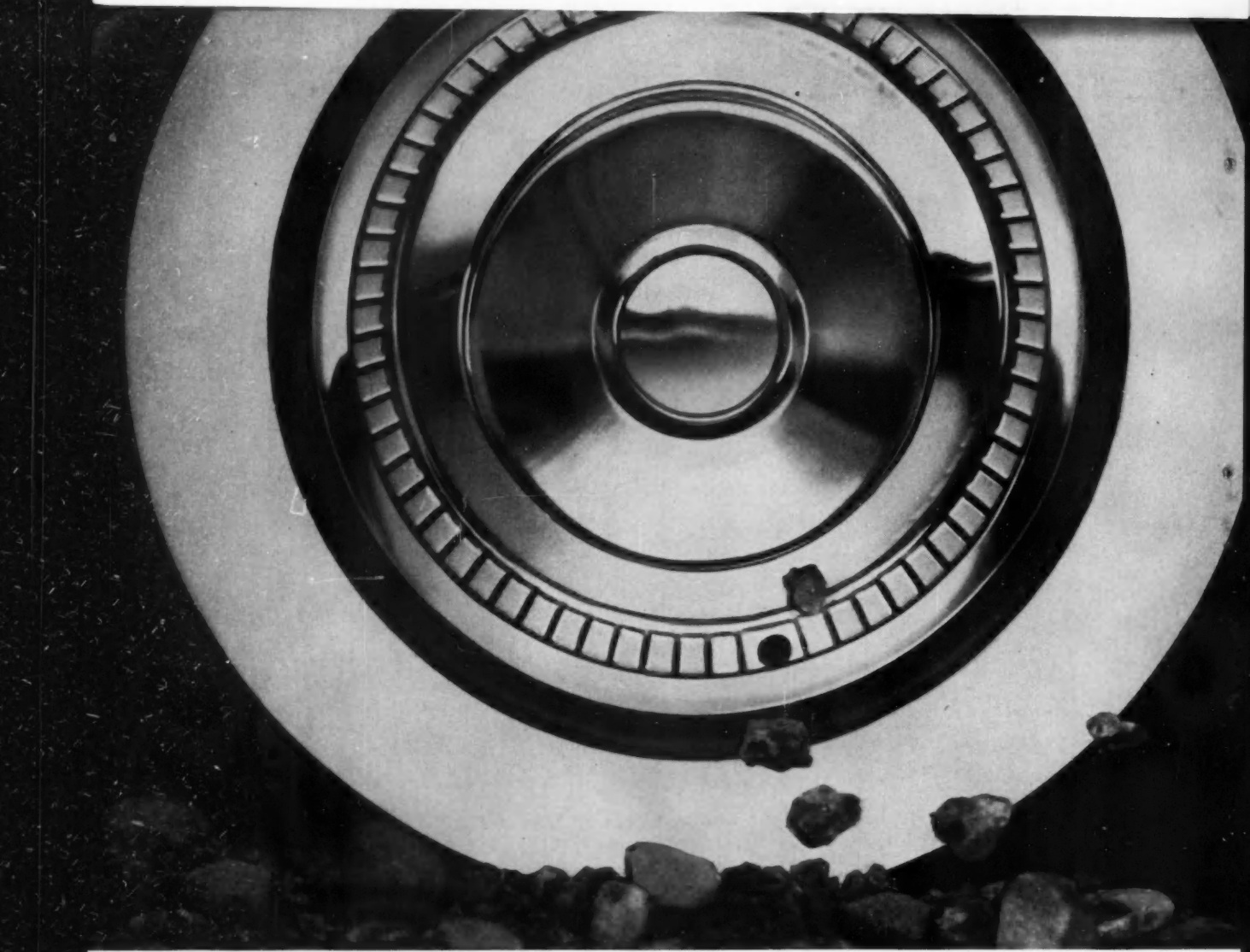
The higher education of computers currently involves studies in symbol manipulation, problem-oriented languages, character and pattern recognition, and engineering simulation.

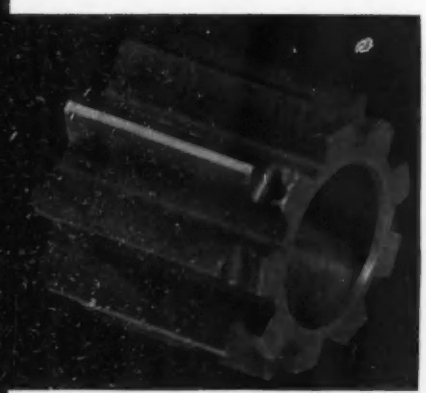
Such advanced computer concepts are giving General Motors professional people more time for creative engineering and research—time to explore ideas and to develop "more and better things for more people."

General Motors Research Laboratories

Warren, Michigan

Comparison of program tapes for a vibrational problem expressed in DYANA language, in algebraic-oriented language, and in the basic machine language.





THE "BEAUTY" OF REPUBLIC COLD DRAWN ALLOY STEEL in this drive pinion is strength and toughness needed to withstand severe torque, impact, and prolonged wear — plus the benefit of better machinability at reasonable cost. In addition to alloy, Republic offers cold drawn carbon, stainless, and titanium bars.

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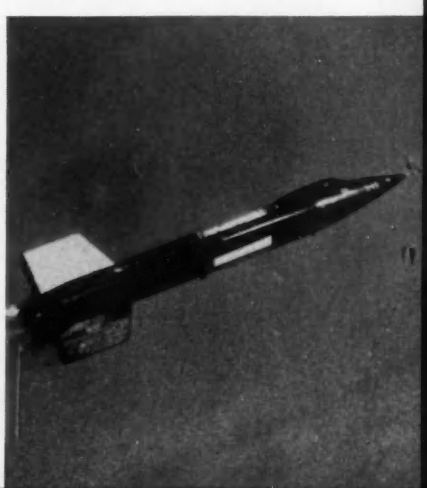
THE "BEAUTY" OF TITANIUM in North American Aviation's X-15 research vehicle is its dependability under extreme high and low temperature fluctuations. Republic—the world's largest producer of stainless and alloy steels—is supplying type RS-110A titanium alloy for the X-15.



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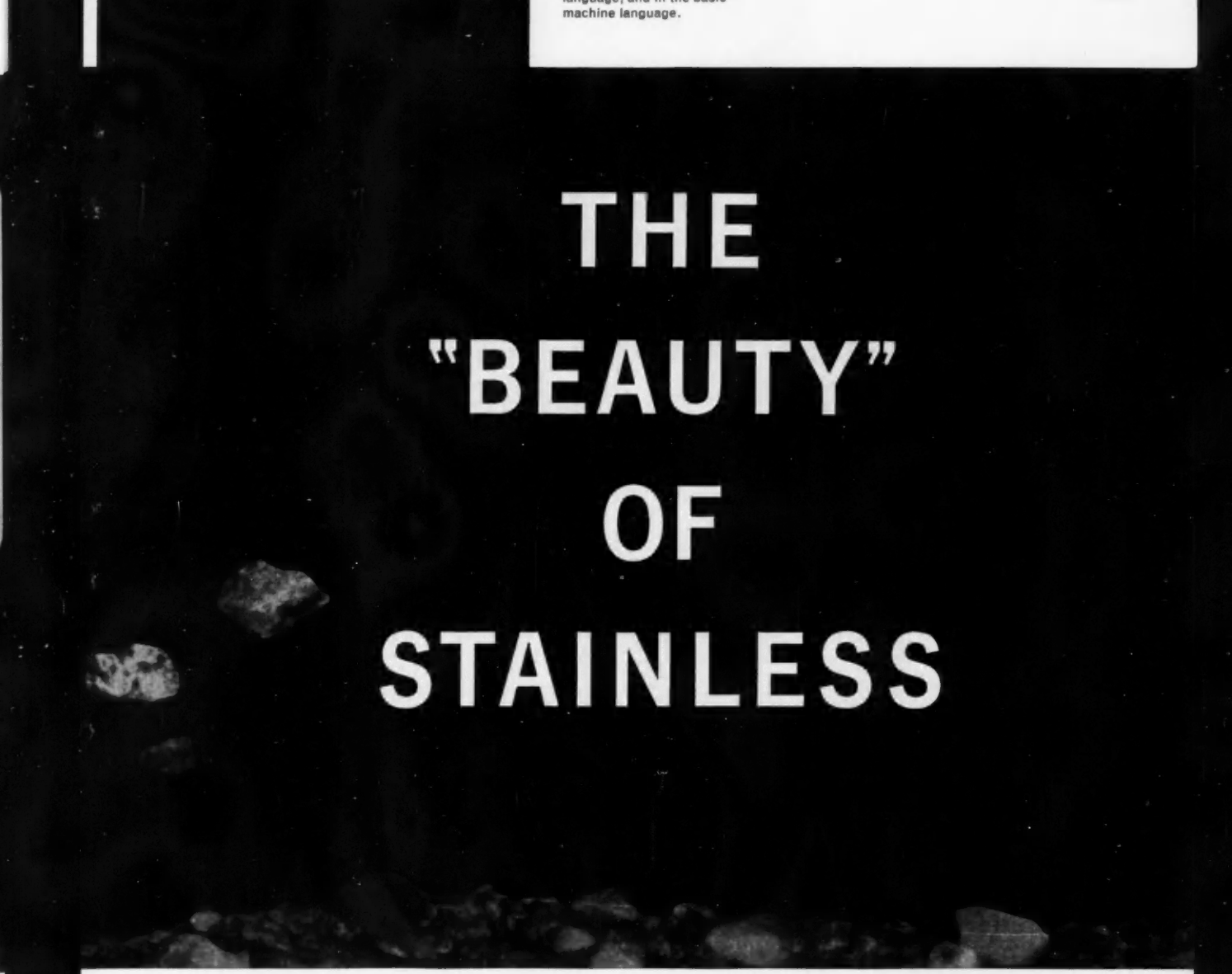

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PLAN NOW FOR YOUR MOVE TO DETROIT'S COBO HALL IN 1961...

Here's What Ward's Automotive Reports Have to Say About the Move:

SAE Annual Convention Booked at Detroit's Cobo Hall, 1961-1965

The Society of Automotive Engineers has engaged Detroit's Cobo Hall for its annual conventions from 1961 through 1965.

The move will give SAE the opportunity of sponsoring what could be the most prominent automotive engineering display in the country and would undoubtedly add authority to Detroit's standing as the motor capital of the U.S. and heart of the industry.

The modern Detroit Civic Center site, currently under construction in the city's bustling downtown waterfont section, is scheduled for opening in August, 1960.

January Dates Set

The SAE business dates firmed up at this time for the 1961-1965 conventions are: 1961 – Jan. 9-13; 1962 – Jan. 8-12; 1963 – Jan. 14-18; 1964 – Jan. 13-17; 1965 – Jan. 11-15.

Cobo Hall will provide the SAE sessions with 400,000 sq. ft. of exhibit space contrasted to just over 10,000 sq. ft. at Detroit's Sheraton-Cadillac Hotel, where the January meeting was held this year.

Membership Swells

It would not be unlikely that SAE will rent exhibit space during its convention to various trades connected with the auto industry for individual expositions.

Textile manufacturers and leather firms would be able to set up equipment to detail their fabric-making processes; rubber makers could show how a tire is made; similar exhibits could be allotted to the replacement parts business; car manufacturers, themselves, might devise cutout working models of engines or even entire automobiles or trucks in simulated motion.

The whole SAE affair could, in fact, house minor conventions for just about every engineering trade allied with the automotive and accessories business.

SAE's expanding membership has been a primary factor in the society's search for larger convention quarters. As of Jan. 1, there were 23,000 members, with the count swelling every month.

Excerpt—Wards Automotive Reports
March 30, 1959

Why Not an Automotive Engineering World's Fair at Detroit's Cobo Hall

Such a structure as Cobo Hall, situated as it is in the manufacturing heart of the auto industry, could be a perfect place for a gigantic technical exhibition —practically a world's fair of automotive engineering – sponsored by the Society of Automotive Engineers.

What a progressive industrial advance would be made by SAE's promotion of a colossal automotive engineering convention-exhibit, particularly with such a valuable location as Cobo Hall available!

Suppliers Could Participate

Parts makers, rubber and tire firms, textiles and leather companies, the metals trades – all of these groups and everyone else with a piece of automotive equipment to show or sell could be provided with the space sufficient to properly present and if necessary, demonstrate his advanced design product.

Cobo Hall's foundations are strong enough to hold heavy equipment such as huge body element stamping presses and various types of rugged metal working machines. The machinery could turn out stampings or tools right in the exhibit area.

If SAE could come up with such a spectacle it would certainly sweep crowds into Detroit, throngs from various areas of industry and business. The affair could, in fact, house minor conventions for every technical trade allied with the auto and accessories field.

SAE selected Cobo Hall for 1961 and subsequent conventions not only because of its vast exhibit area but for other accommodations as well, including several meeting rooms that seat over 500 persons and a banquet and adjacent room that can hold and serve over 5,000. *Excerpt*—Ward's Automotive Reports

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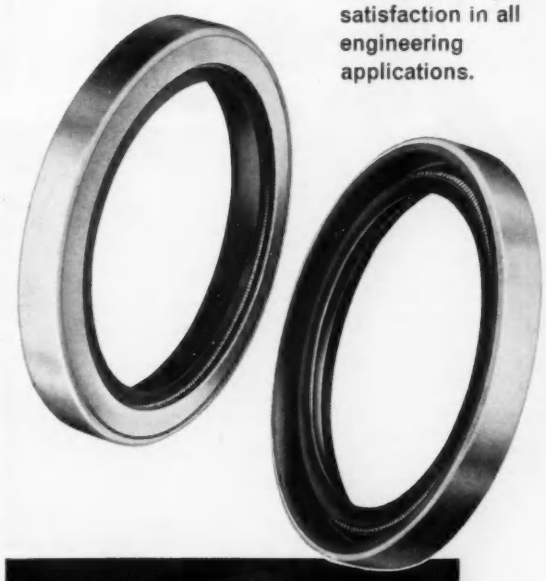

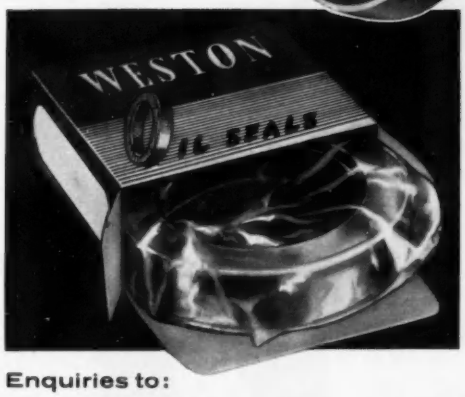

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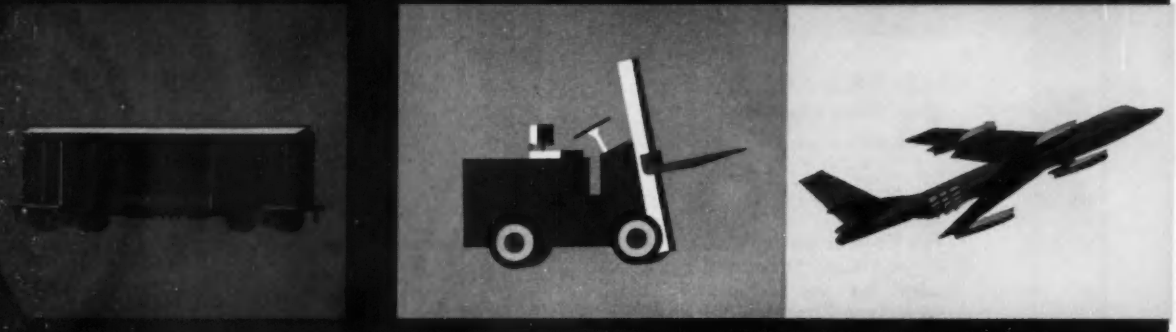

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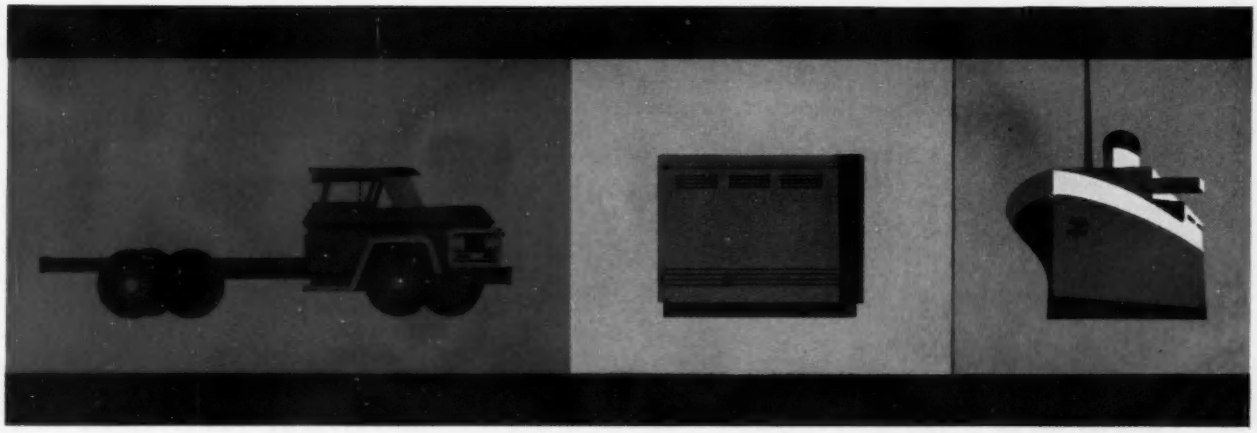

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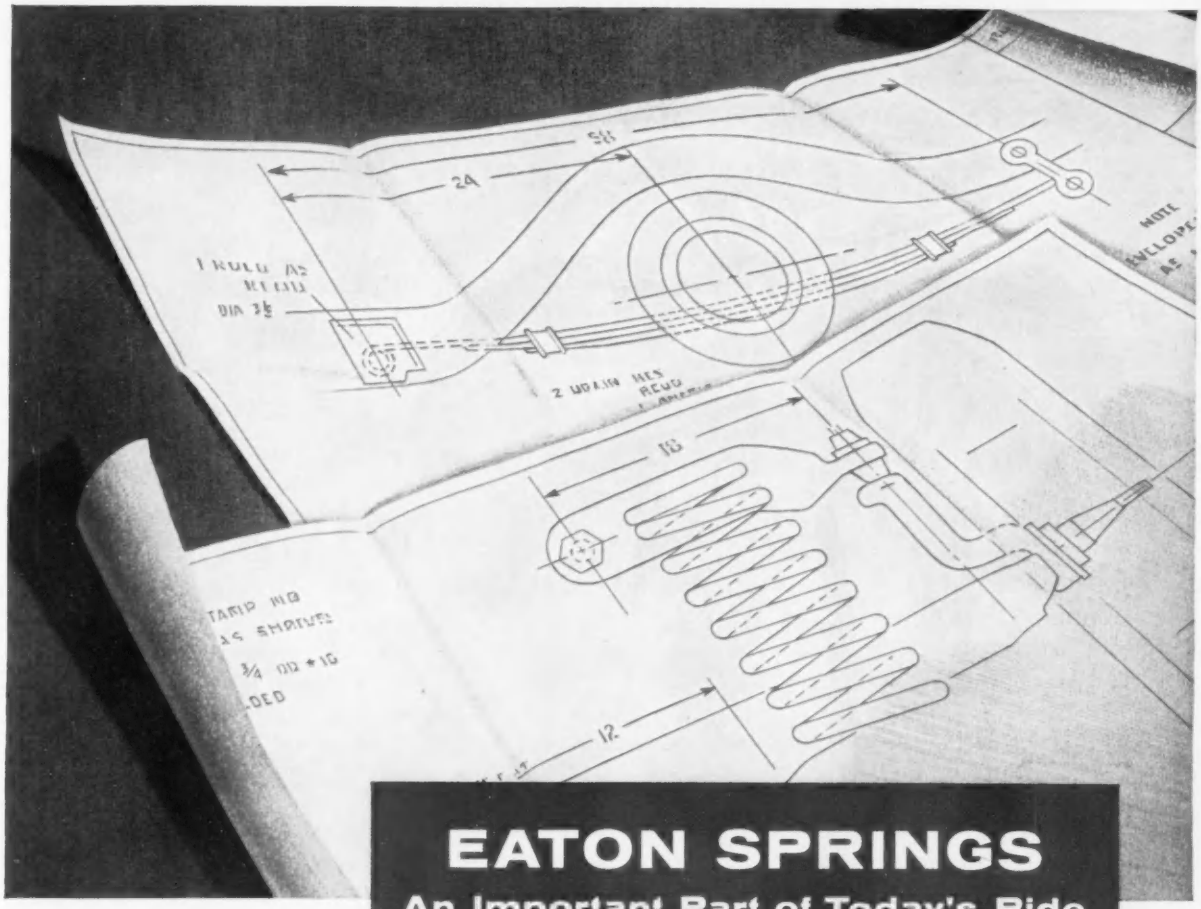

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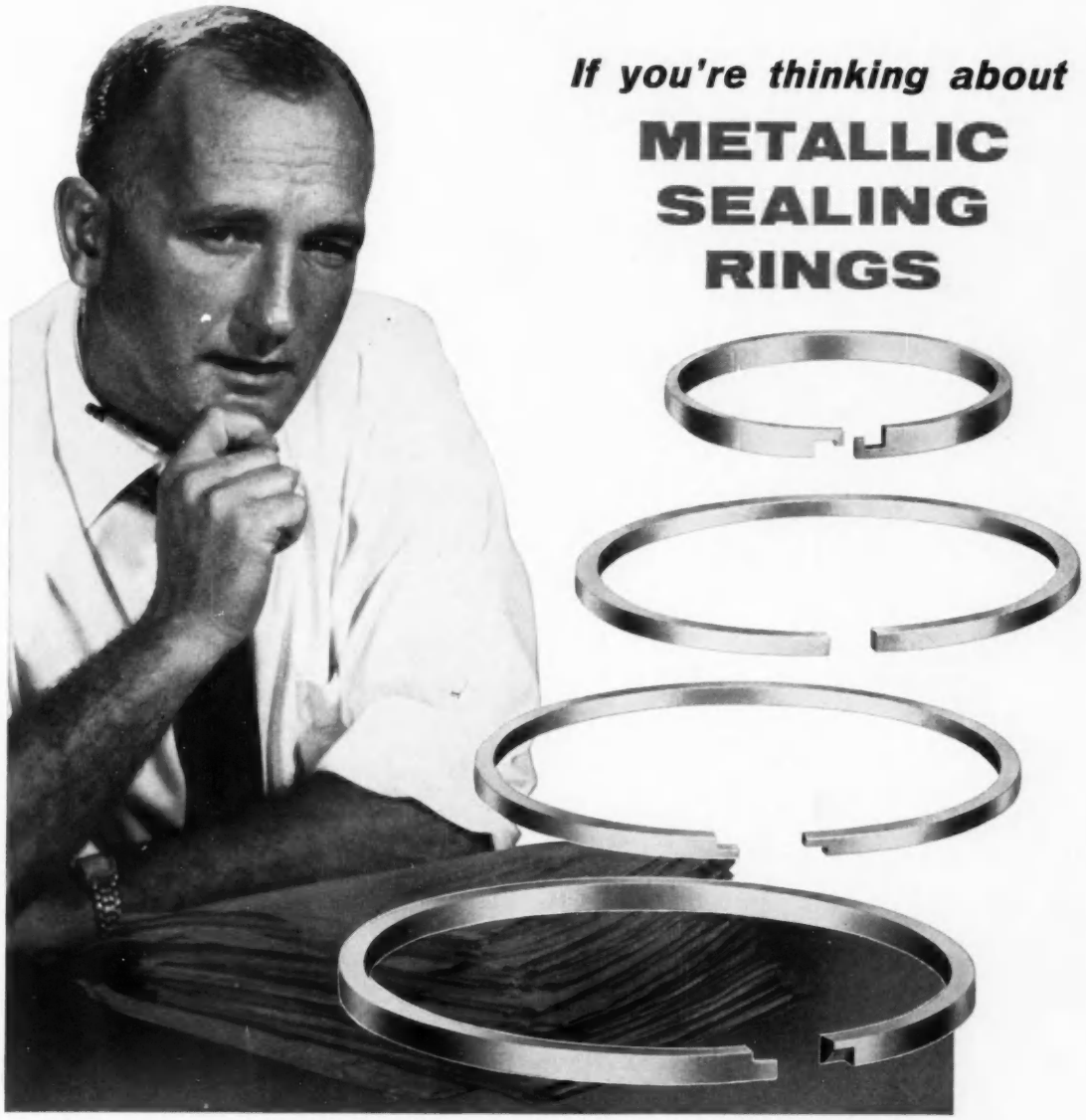

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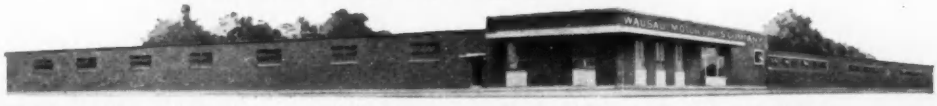

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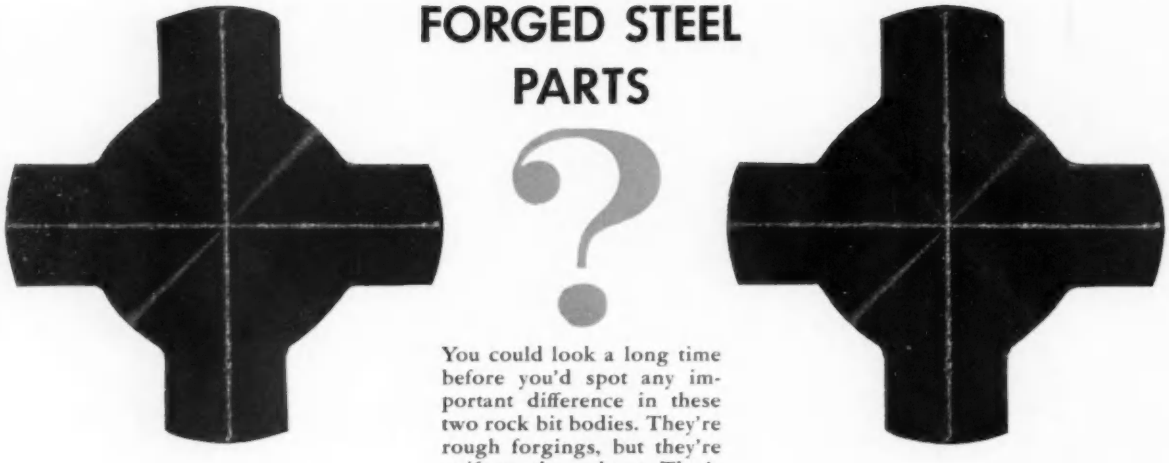

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